BTeV Tracking System

Pixel Vertex Detector (WBS 1.2)

Straw Tracker (WBS 1.6)

Silicon Tracker (WBS 1.7)

Simon Kwan (WBS 1.2)

Alan Hahn (WBS 1.6)

Luigi Moroni (WBS 1.7)

Overview

- **Brief description of the BTeV tracking system**
  - Pixel vertex detector
  - Forward tracker (Straw & Silicon strips)
- **Details of each sub-system**
  - Project overview (scope, organization)
  - Technical Design overview
  - Cost, Schedule, Critical path, and Risk Analysis
- **Presentations prepared for the breakout sessions**
- **Conclusion**
- **Glossary**

Introduction

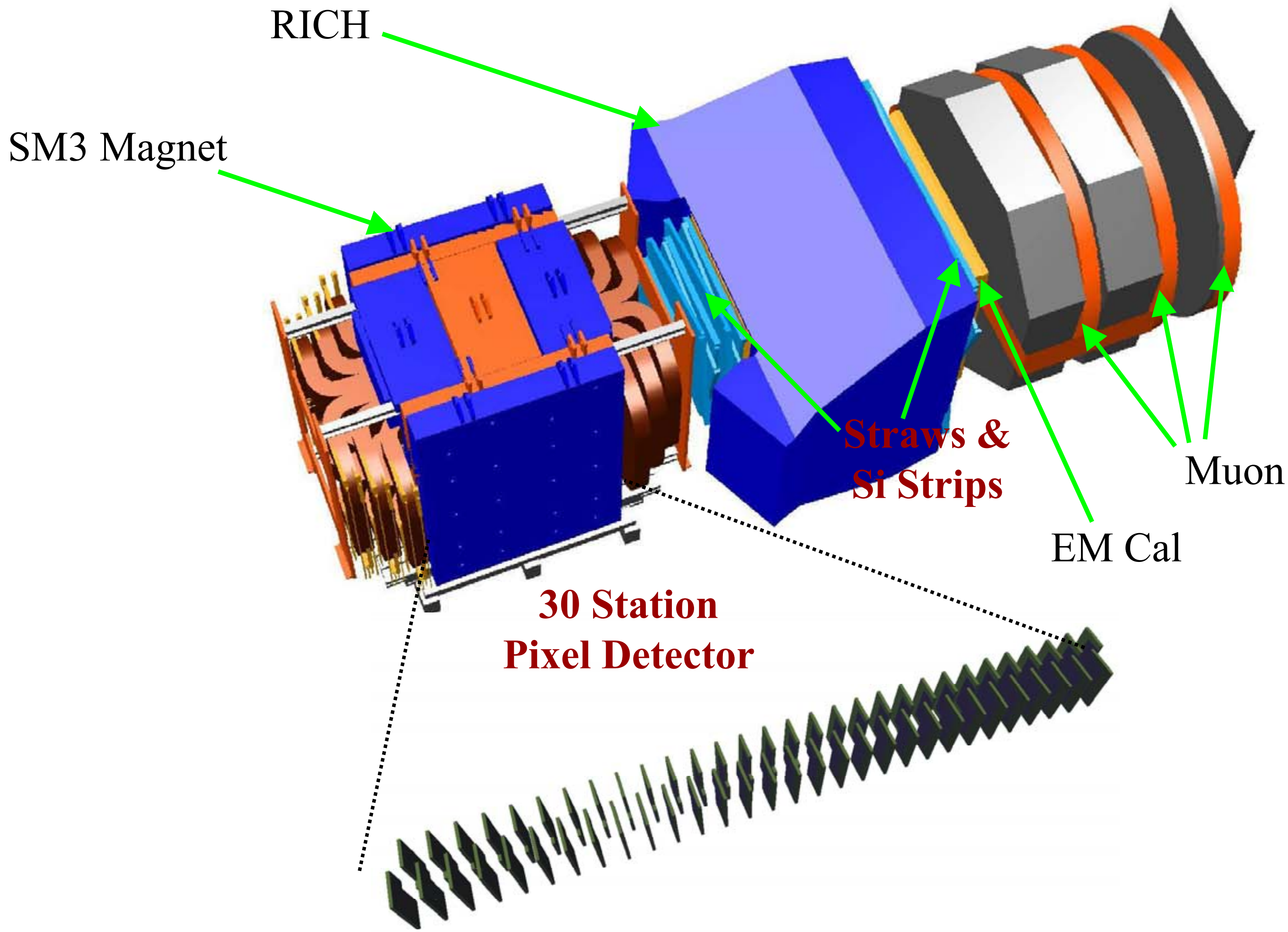
Requirements

- **Coverage**:
  - Aperture 300 mr
  - Momentum acceptance 3 - >100 GeV/c
- **Tracking efficiency > 98%**
- **Resolution for vertex detector:**
  - Spatial : < 9 μm
  - Time: < 50 fs
- **Vertex detector info available for use in L1 trigger**
- **Angular resolution**:
  - Better than 0.1 mr
- **Momentum resolution**:
  - 1% at 100 GeV/c
- **Can handle huge data rate and survive high radiation dosage**

Key features

- **Vertex Detector**
  - **Pixel Detector (WBS1.2)**
    - Precise vertex detection and reasonable momentum measurement capability
    - Fast info available for use in L1 vertex trigger
- **Forward Tracker**
  - **Straw (WBS1.6) and Silicon Strip (WBS1.7)**
    - Precise momentum measurement, Ks/Λ detection, project tracks into RICH, EMCAL, Muon chambers
    - Combination of **Silicon strips** near the beam and **Straw Chambers** at large radius

BTeV Detector



Pixel Components WBS 1.2

- WBS 1.2.1: Sensor & Detector Hybridization
  - Includes design, procurement and testing of sensor wafers, flip-chip mating of sensors to readout chips to get pixel modules
- WBS 1.2.2: Electronics
  - Includes pixel readout chips, data cables, PIFC, PDCB, HV/LV power supplies and cables
- WBS 1.2.3: Mechanical & Vacuum system
  - Includes substrate, fixtures, vacuum vessel, position control system, cooling system, vacuum system, support structure, rf shield, and feed-through board.
- WBS 1.2.4: System Integration
  - Includes production HDI, pixel module assembly and testing, test-stands, station assembly, detector assembly, beam test, control &monitoring, fast interlocks, system test, system software
- WBS 1.2.5: Project Management

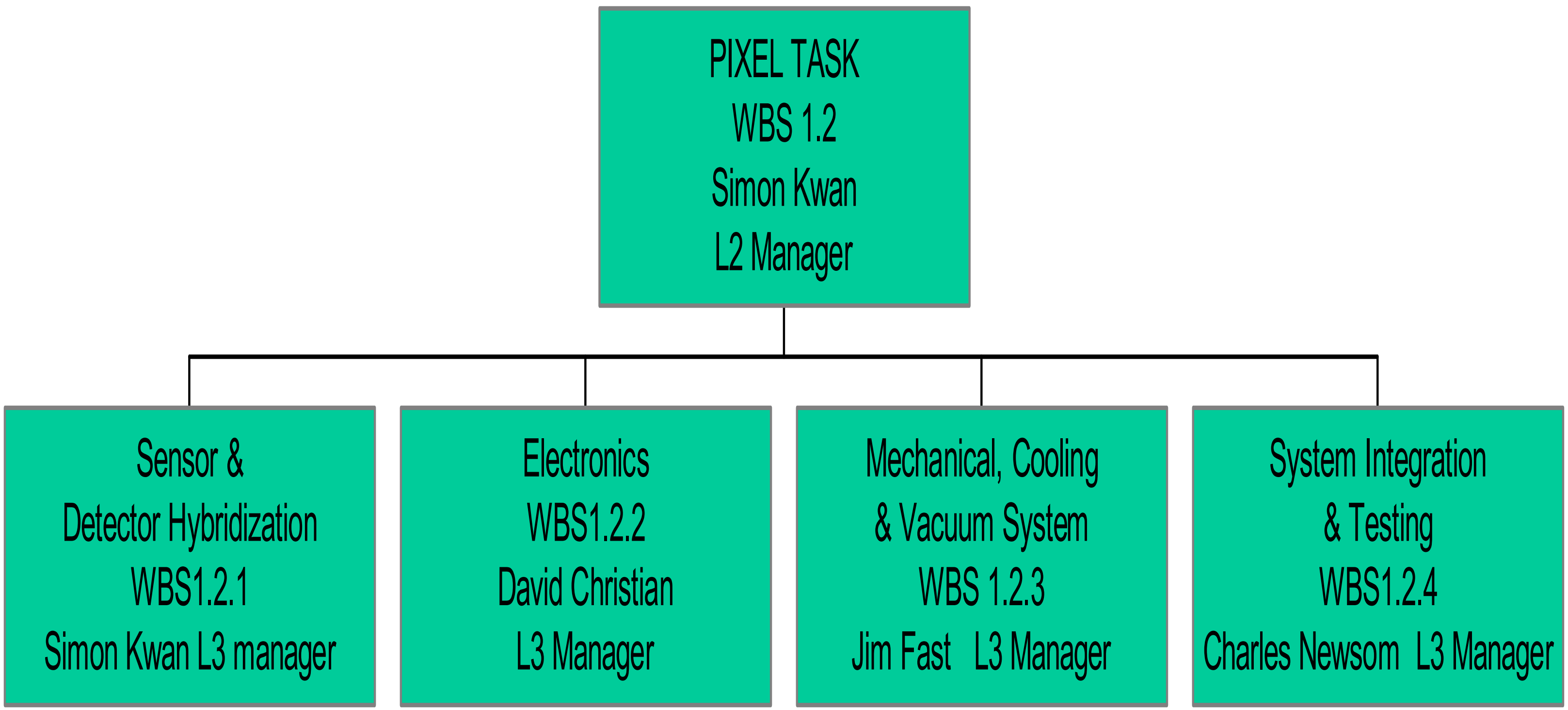
Pixel Detector Participants WBS 1.2

Fermilab: J. A. Appel, D. C. Christian, S. Cihangir, J. Fast, R. Kutschke, S. Kwan, M. Marinelli, L. Uplegger, J. Andresen, M. Bowden, G. Cardoso, H. Cease, C. Gingu, J. Hoff, A. Mekkaoui, M. Turqueti, R. Yarema, J. Howell, C. Kendziora, M. Kozlovsky, M. Larwill, C.M. Lei, A. Shenai, A. Toukhtarov, M.L. Wong , S. Austin, S.Jakubowski, R. Jones, G. Sellberg, M. Ruschman
Frascati: S. Bianco, F. Fabbri, M. Caponero, D. Colonna, A. Paolozzi
Iowa: C. Newsom, M. Divoky, J. Morgan
Milano: G. Alimonti, S. Magni, D. Menasce, L. Moroni, D. Pedrini, S. Sala
Syracuse: M. Artuso, C. Boulahouache, J.C. Wang
Tennessee T. Handler, R.Mitchell, S. Berridge
Wayne State: D. Cinabro, G. Bonvicini, A. Schreiner, A. Guiterrez, G. Gallay, S. LaPointe

-Physicist

- Technical staff

Pixel L2 & L3 Managers WBS1.2



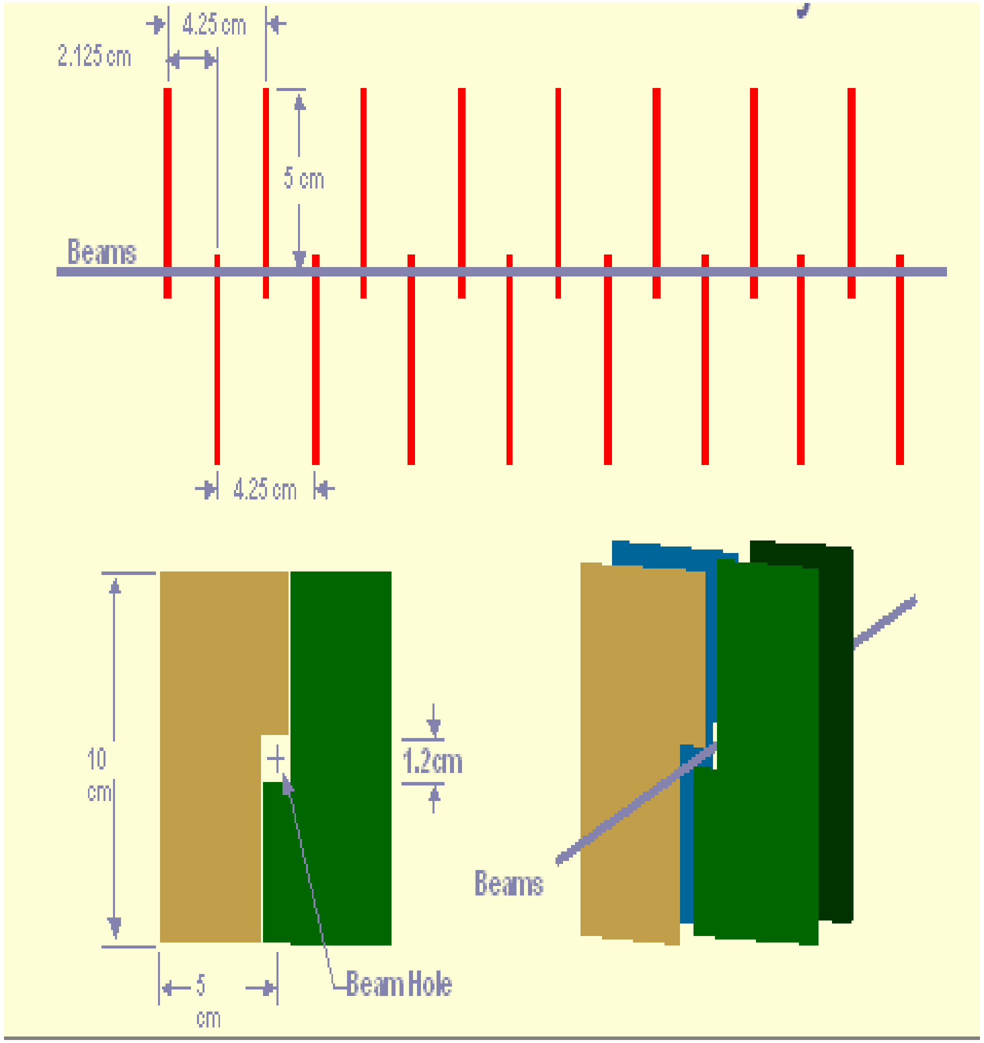
Base cost: $15.45M (Material: $8.00M, Labor: $7.45M)

Reasons for Pixel Detector:

- Superior signal to noise
- Radiation Hard
- Excellent spatial resolution: <9 μm for all tracks
- Pattern recognition power
- Very low occupancy

Special features:

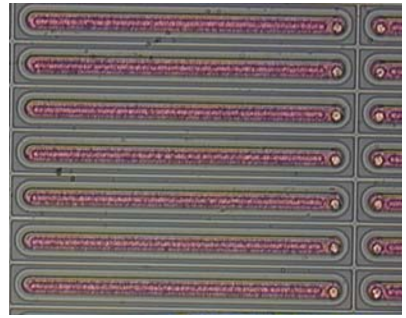
- Info used directly in the L1 trigger
- Placed inside a dipole and gives standalone momentum measurement
- Sitting close to beam and be retractable during beam refill -> needs vacuum system and rf shielding
- 30 stations with 23 million pixels in total
- Total length ~1.3m



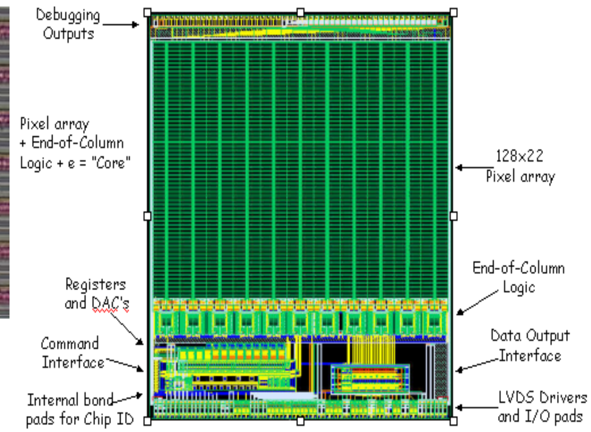
Pixel Detector WBS 1.2

- Pixel Sensor bump-bonded to Readout chip
- Fine segmentation
  - 50 µm x 400 µm
  - Large number of channels
  - Electronics in the active tracking volume
  - High power density (cooling system)
- Basic building block – Multichip Module (MCM)
  - Large number of HDI and flex cables
- Assemble modules on substrate to form pixel half plane; an x-measuring half-plane and a y-measuring half-plane form a half-station

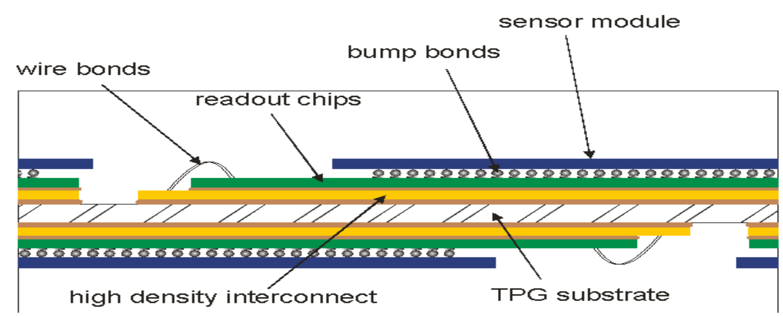
Si pixel sensors



Pixel Readout chip



Multichip module



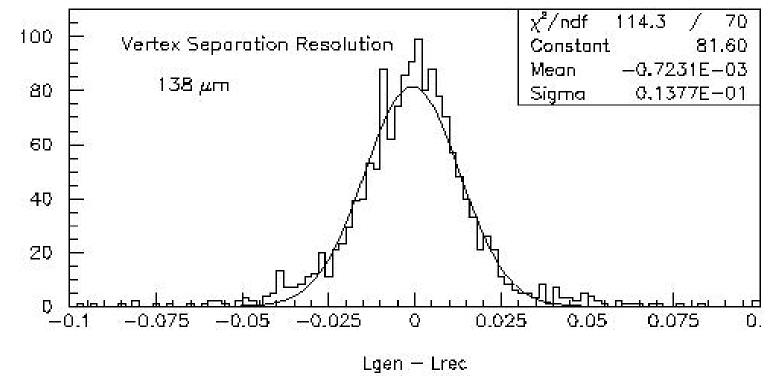
Pixel Detector Properties & Performance WBS1.2

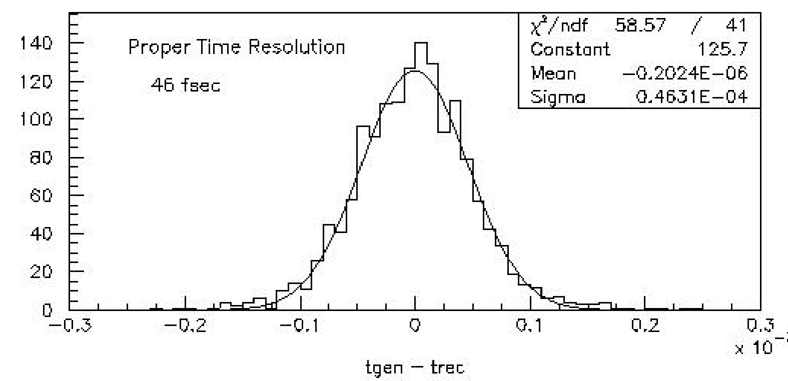
Property	Value
Pixel Size	50 µm x 400 µm
Outer plane dimension	10 cm x 10 cm
Central square hole (adjustable)	Nominal setting: 12 mm x 12 mm
Number of planes	60
Number of stations	30
Number of pixels	23 million
Total Silicon active area	0.5 m^2
Separation of stations	4.25 cm

$B_s \rightarrow D_s\ K^+$

Primary-secondary vertex separation

Reconst - generated. $\sigma = 138\mu$



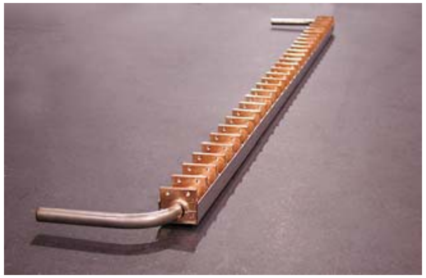


τ_{proper} **(reconstructed) -** τ_{proper} **(generated)**

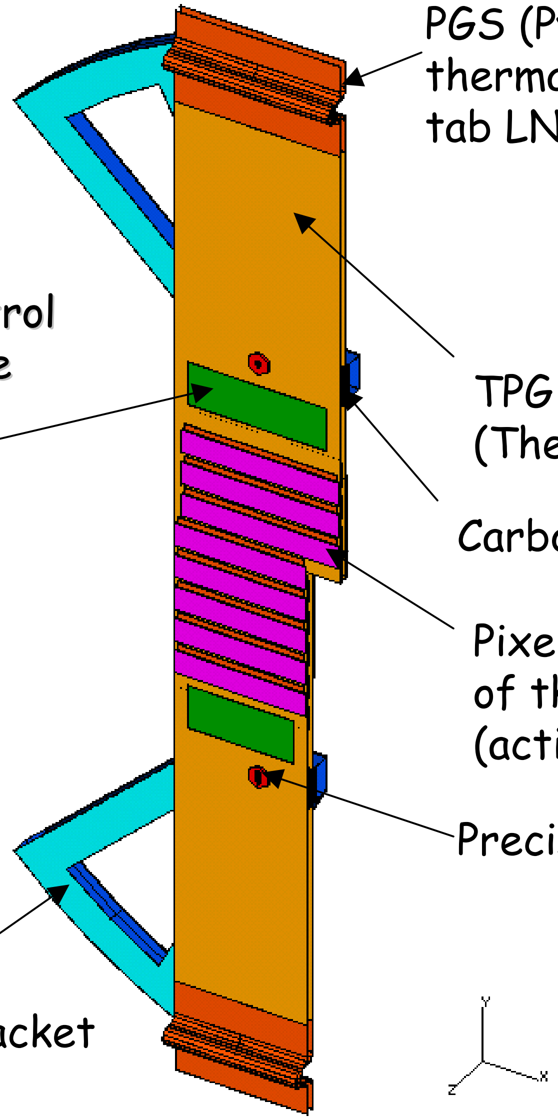
σ **= 46 fsec**

Pixel Half-Plane WBS1.2

PGS (Pyrolytic Graphite Sheet) flexible thermal coupling attached to copper tab LN2 heat sink



The temperature control elements modulate the temperature of the substrate



TPG (Thermal Pyrolytic Graphite)

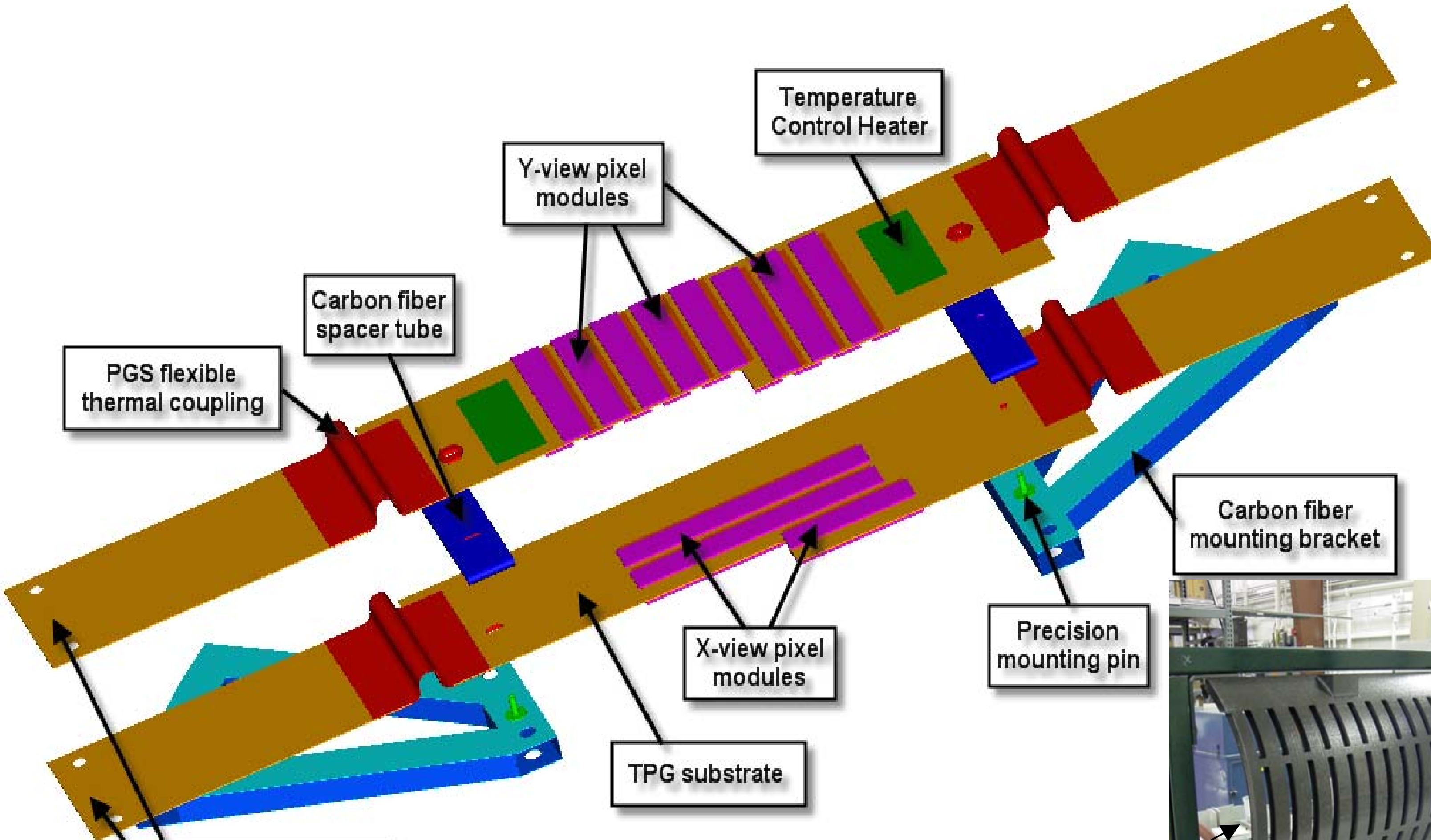
Carbon fiber spacer

Pixel modules placed on both sides of the TPG substrate (active region: ~10 cm long)

Precision hole & slot washers

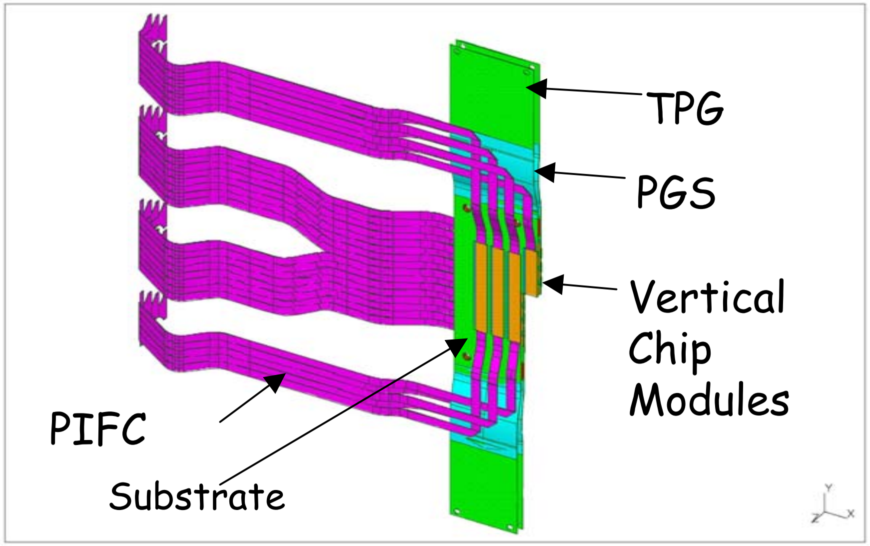
Carbon fiber bracket

Pixel Half-Station WBS1.2

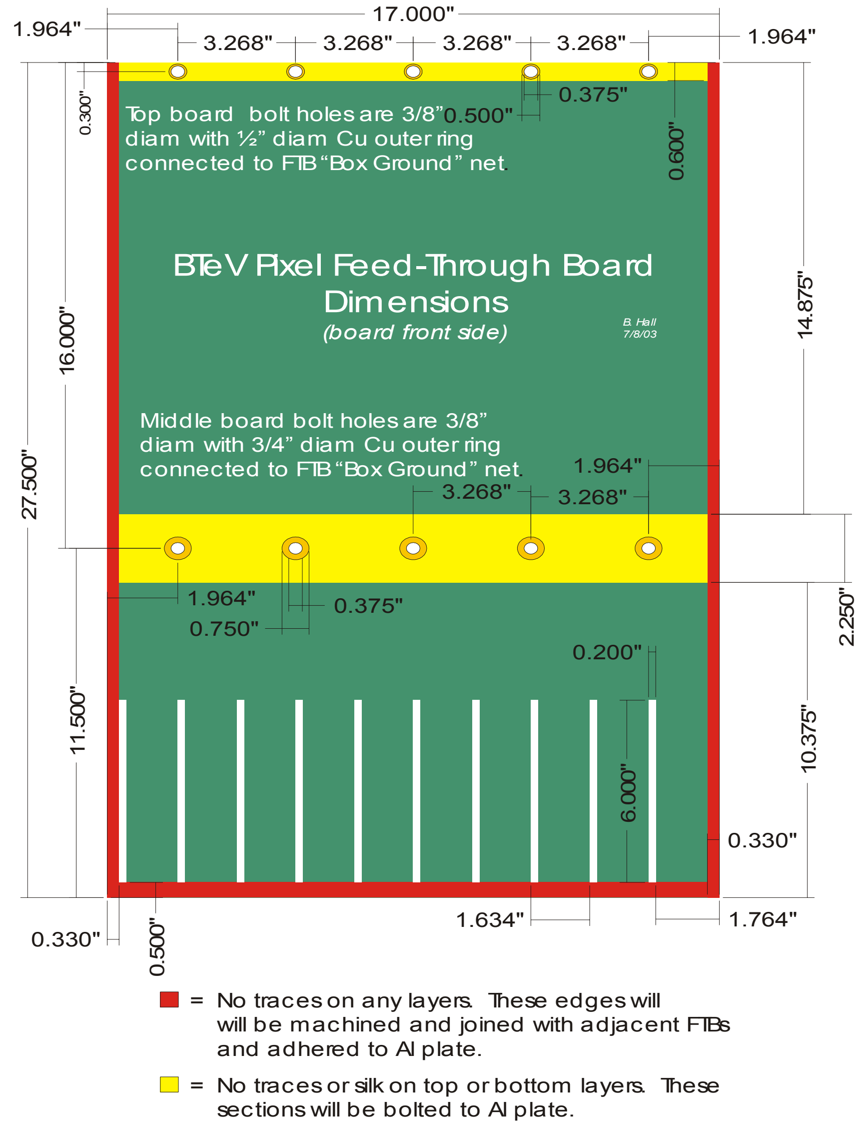


Carbon support half cylinder (~1.26m long)

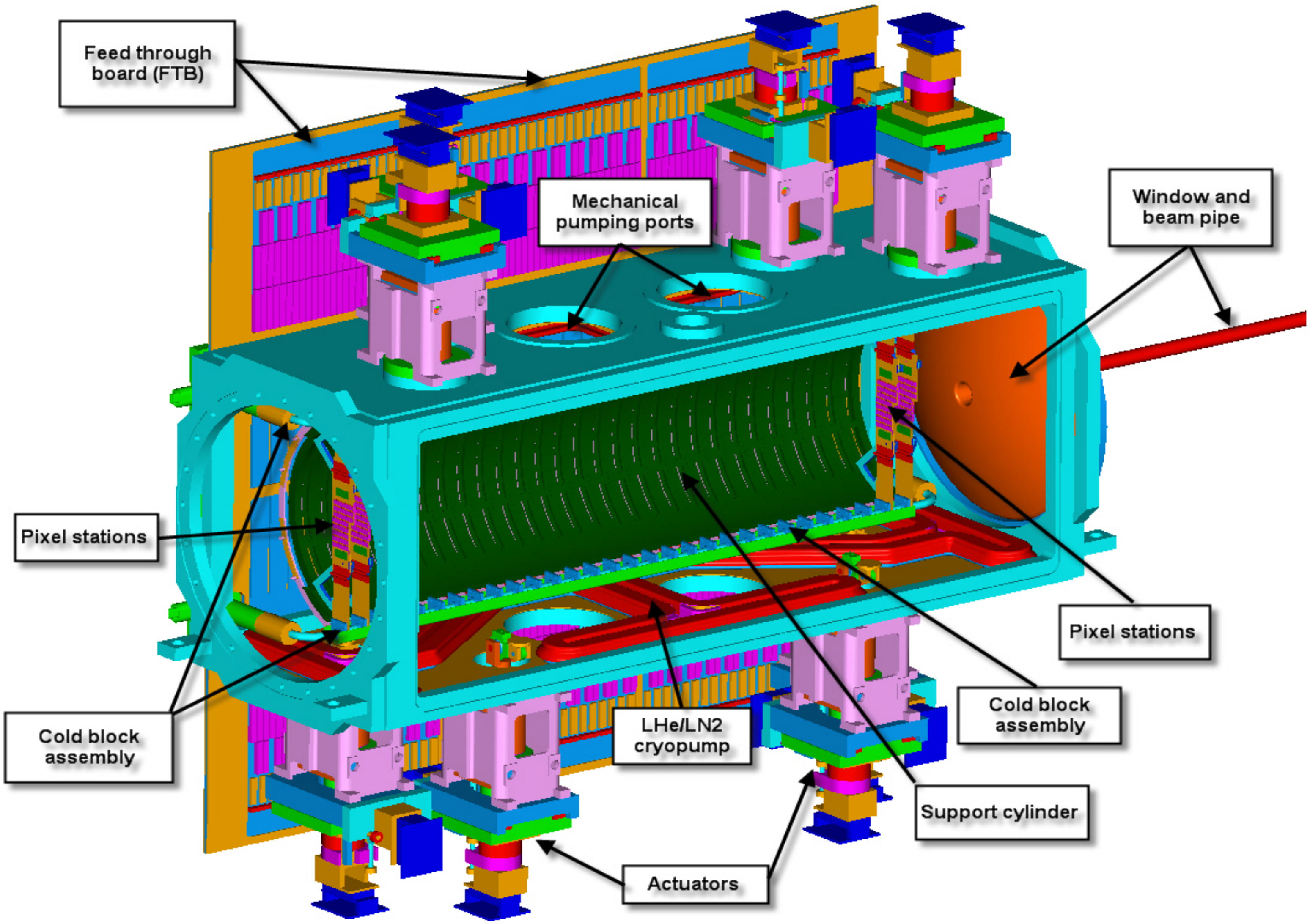
Feed-through Board (FTB) WBS1.2



- Signal path: ROC- HDI- PIFC- FTB- PDCB-trigger/DAQ system
- Board size: 17”x27.5”; 36 layers
- Full size FTB prototype will be delivered next month
- Key for mechanical and electrical tests
- FTB layout is very dense and can benefit from any possible simplification



Pixel Detector Assembly

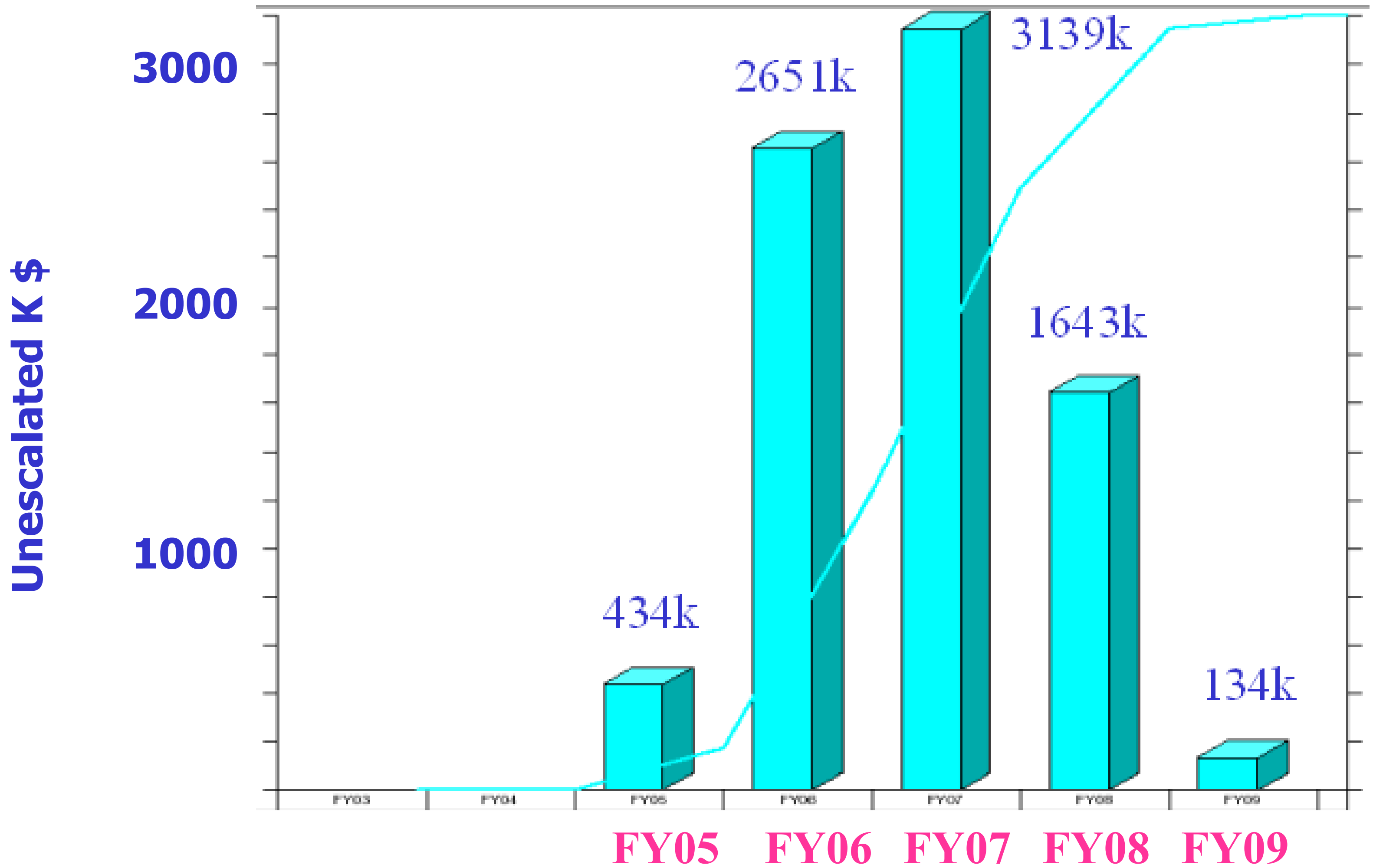


Pixel Construction Cost WBS 1.2

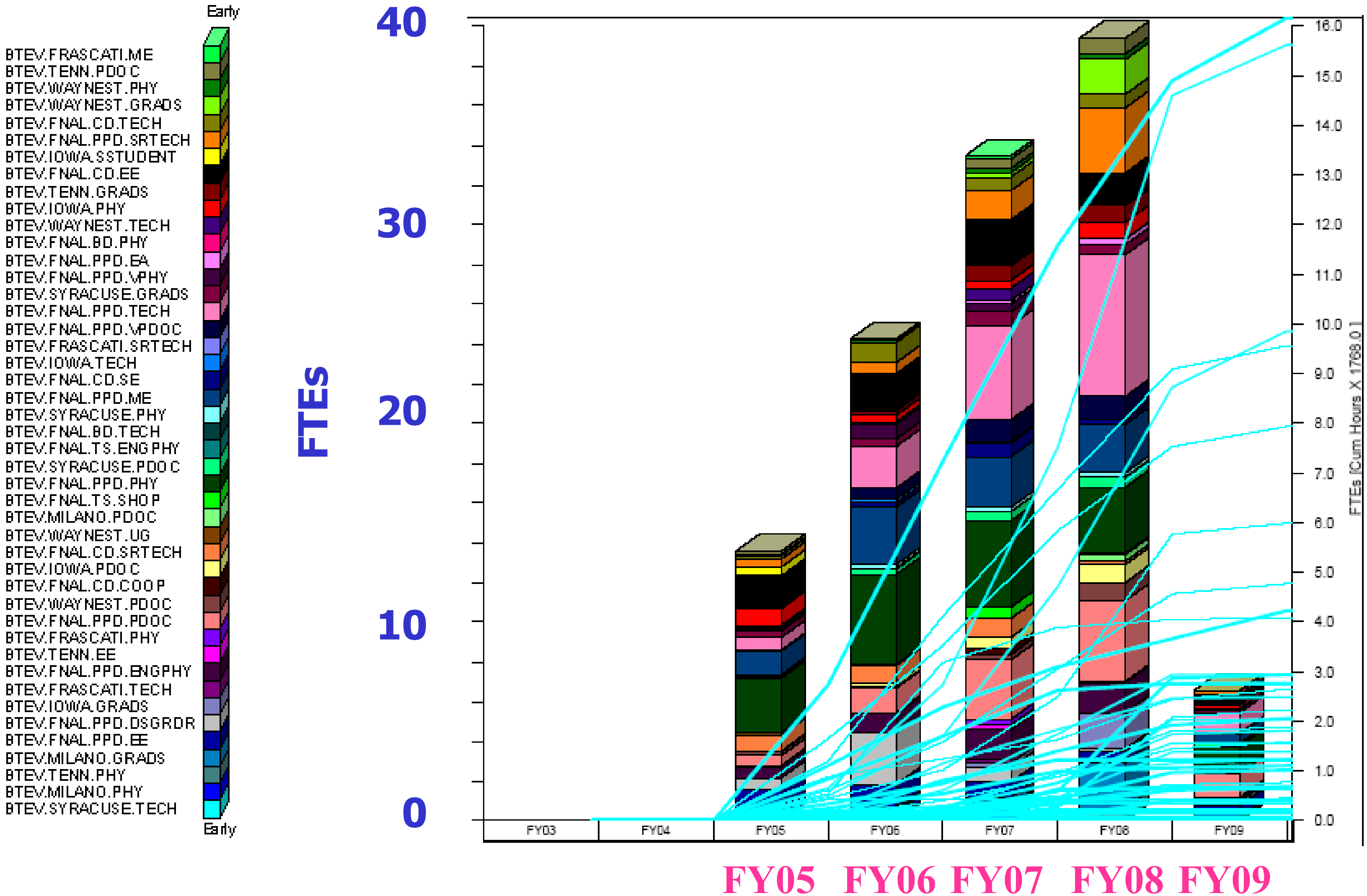
Activity ID	Activity Name	Base Cost ($)	Material Contingency (%)	Labor Contingency (%)	Total FY05	Total FY06	Total FY07	Total FY08	Total FY09	Total FY05-09
1.2.1	Sensors and Pixel Detector Hybridization	2,275,496	47	31	229,083	1,158,577	1,820,826	82,272	0	3,290,758
1.2.2	Pixel Detector Electronics	4,233,927	37	37	762,670	2,022,781	1,171,484	1,843,142	0	5,800,077
1.2.3	Mechanical Cooling and Vacuum System	4,574,493	46	37	356,765	1,843,255	2,861,453	1,302,595	66,506	6,430,575
1.2.4	System Integration & Testing	3,571,635	46	45	323,461	1,045,414	1,427,008	1,807,736	579,214	5,182,834
1.2.5	Pixel Detector Subproject Management	799,673	23	18	206,466	209,757	207,289	207,289	115,161	945,962
1.2	**Subproject 1.2**	**15,455,224**	**42**	**38**	**1,878,446**	**6,279,783**	**7,488,061**	**5,243,034**	**760,881**	**21,650,205**

M&S Obligation Profile by Fiscal Year WBS 1.2

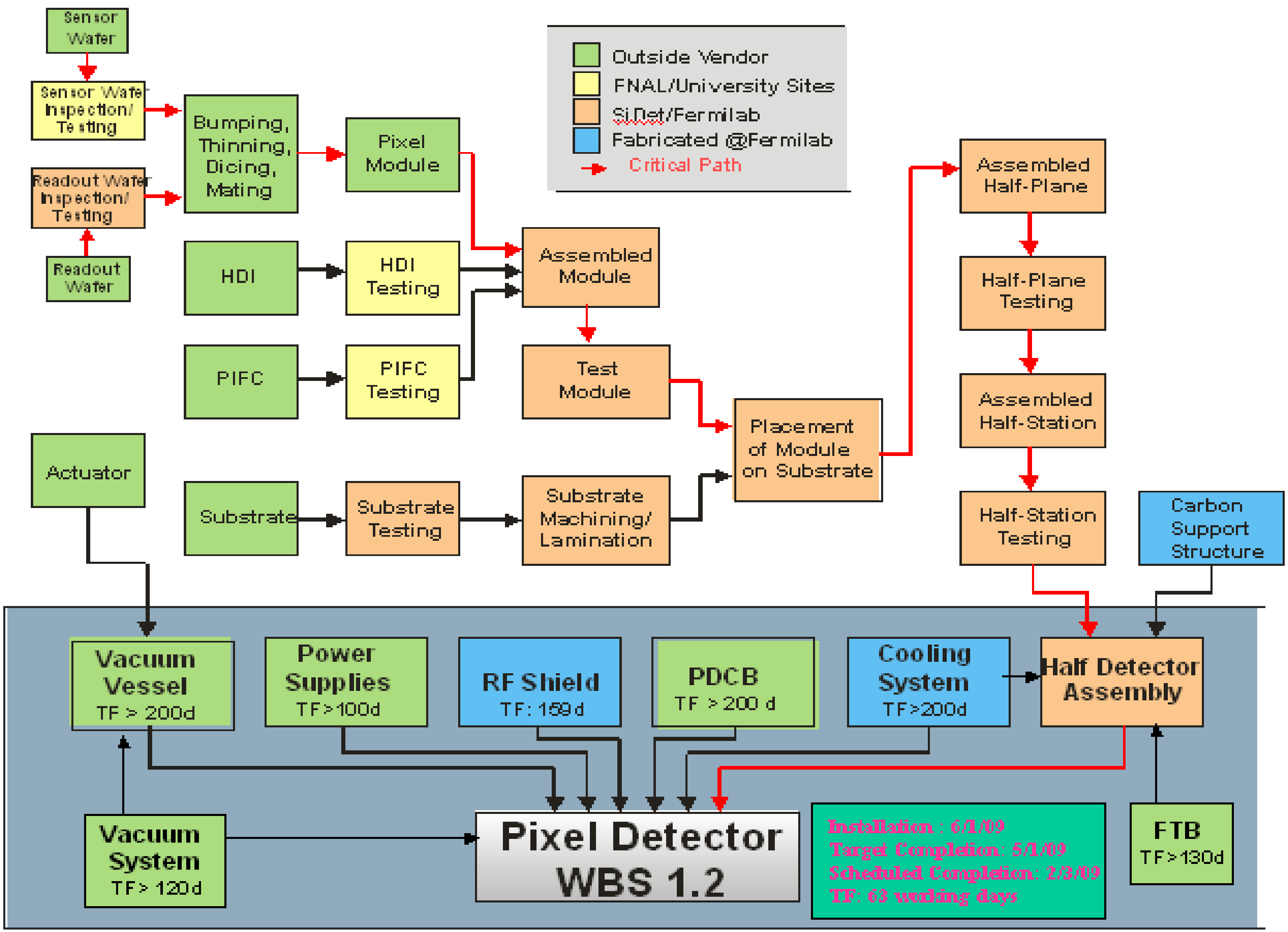
Total: 8002 k$



Labor Profile by Fiscal Year WBS 1.2



Description of Project Flow WBS 1.2



BTeV / CO

Gantt Chart for Pixel Critical Path WBS1.2

BTeV - WBS 1.2 Pixel Detector

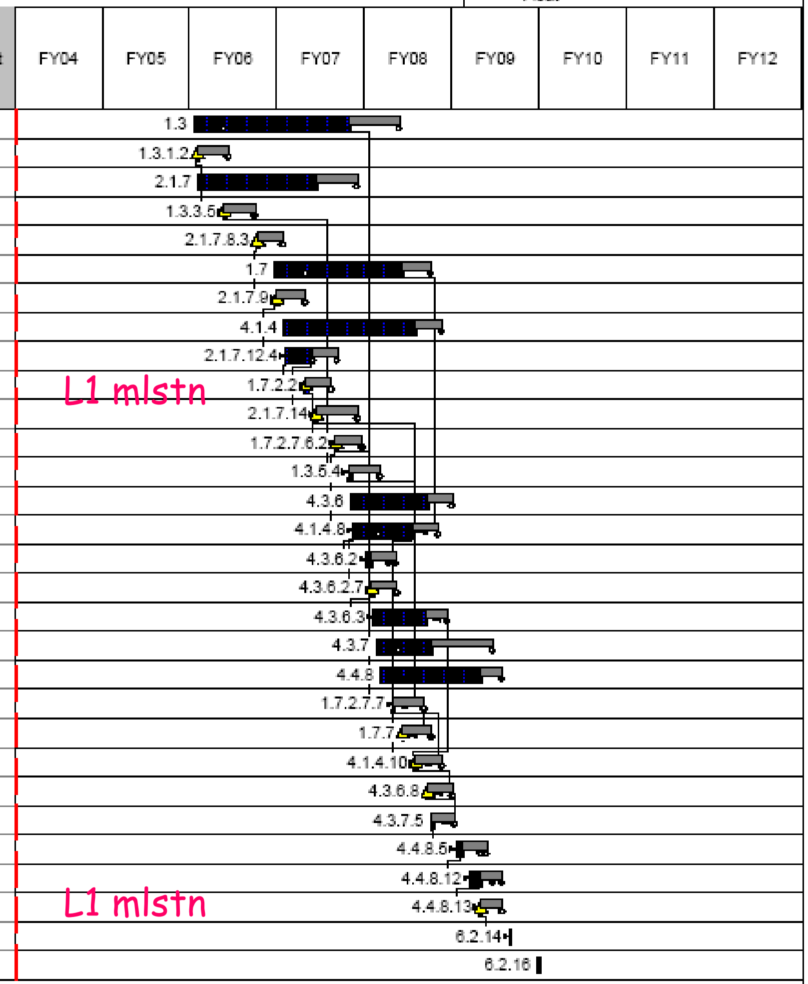
Critical Path - Gantt Chart

Only selected activities/milestones are shown

16Apr04

Planned
Critical
Late Dates
Milestone
Progress
Summary
Float

Activity ID	Activity Description	Duration	Early Start	Early Finish	Float
1.3	Production Sensors - FNAL	452d	20Oct05	31Jul07	88d
1.3.1.2	Lev4MII:Pixel sensor ready for Production	0	04Nov05	04Nov05	88d
2.1.7	PRC Production - FNAL	340d	09Nov05	13Mar07	73d
1.3.3.5	Lev2MII: Contracts Placed for Production pixel sensors	0	23Feb06	23Feb06	88d
2.1.7.8.3	Lev2MII: Contract awarded for production pixel ROC	0	12Jul06	12Jul06	73d
1.7	Hybridization of Production Detectors	364d	26Sep06	07Mar08	73d
2.1.7.9	Lev4MII: Receive all FPIX wafers	0	05Oct06	05Oct06	73d
4.1.4	PM Production Units - FNAL	374d	07Nov06	02May08	72d
2.1.7.12.4	Test the Wafer & Mark Known-Bad-Dies	75d	13Nov06	02Mar07	73d
1.7.2.2	Lev2MII: Contract placed for production detector hybridization	0	31Jan07	31Jan07	73d
2.1.7.14	Lev4MII: Production PRC completely tested	0	13Mar07	13Mar07	121d
1.7.2.7.6.2	Lev4MII: first lot of pixel detectors delivered	0	06Jun07	06Jun07	73d
1.3.5.4	Lev3MII: Production sensors wafers completely delivered	0	31Jul07	31Jul07	88d
4.3.6	Production pixel station assembly	224d	06Aug07	25Jun08	63d
4.1.4.8	Assembly and Test of PM	169d	22Aug07	24Apr08	72d
4.3.6.2	First pixel station	21d	09Oct07	06Nov07	63d
4.3.6.2.7	Lev2MII: Final pixel detector assembly started	0	06Nov07	06Nov07	63d
4.3.6.3	Assemble modules on substrates to form half- planes	150d	08Nov07	16Jun08	63d
4.3.7	Pixel Station test	162d	21Nov07	16Jul08	63d
4.4.8	Production pixel detector system assembly	285d	11Dec07	02Feb09	63d
1.7.2.7.7	Lev3MII: Receive all Production pixel detectors	0	29Jan08	29Jan08	91d
1.7.7	Lev4MII: All Production pixel detectors tested	0	07Mar08	07Mar08	83d
4.1.4.10	Lev2MII: Production Pixel Module Completed	0	02May08	02May08	76d
4.3.6.8	Lev4MII: All pixel stations assembled	0	25Jun08	25Jun08	69d
4.3.7.5	Lev3MII: All pixel stations assembled & tested	0	11Jul08	11Jul08	63d
4.4.8.5	Testing of the half-detector	20d	23Oct08	19Nov08	63d
4.4.8.12	Testing of the assembled detector at SIDET	28d	18Dec08	02Feb09	63d
4.4.8.13	Lev2MII: Pixel detector tested & ready to be shipped to C0	0	02Feb09	02Feb09	63d
6.2.14	Lnk2MII: Start FY09 shutdown	0	01Jun09	01Jun09	0
6.2.16	Lnk2MII: End Construction	0	29Sep09	29Sep09	0



Critical Path Analysis WBS 1.2

- **Target installation date: June 1, 2009**
- Be Ready by (schedule from WBS1.10): May 1, 2009
- Scheduled completion date: Feb 3, 2009 giving a total float of **63** w/days
- Pixel Detector will be installed as one piece (vessel with stations inside)
- Schedule constraint by funding profile, especially FY05
- Pixel Detector has many components but the critical path is the making the pixel modules, placing them on a substrate (half-plane and half-station), and assemble the half-stations into the two half-detectors. This is a sequence of assembly and testing steps. Because we have 1380 modules in total, the duration of the each sequence is long (10 months or more). To keep this tight schedule,
  - A lot of staggering in the activities
  - Place the orders early (sensor, ROC, hybridization)
  - Multiple paths/vendors
  - Sustain the flow of parts and have more than one assembly/test line/shift
  - Engage qualified vendors early in QA and throughput discussion

Key Milestones WBS 1.2

WBS Number	Milestone	Date
1.2.1.3.3.5	Contract awarded for production pixel sensors	Feb 2006
1.2.2.1.7.8.3	Contract awarded for production pixel readout chips	Jul 2006
1.2.1.7.2.2	Contract awarded for production pixel detector hybridization	Feb 2007
1.2.4.3.6.2.7	Production pixel detector assembly started	Nov 2007
1.2.4.1.4.10	Production pixel modules delivered	May, 2008
1.2.4.4.8.13	Pixel detector tested & ready to be shipped to C0	Feb 2009

Pixel Detector Risk Analysis WBS1.2

Risks	Mitigation strategy
Bump bonding vendors not available or have unacceptable yield or throughput	Identify more vendors. Keep close contact with LHC experiments and have information about their schedule and vendors
Cannot achieve the vacuum required due to gas load much bigger than expected and we don't have enough space for larger pumps or cryopanels	Repeat outgassing test with a model which includes close to final components and full size FTB. Prototype the cryopumps
Pixel temperature control, cooling, and vacuum system do not work as designed.	We have put in our plan a system demonstrator program that will happen early in the construction phase to study this and various failure modes.

Straw Components WBS 1.6

Base cost: $9.5M (Material: $5.1M, Labor: $4.4M)

- 1.6.1 - Straw Detectors (7 stations)
  - the physical Detector.
- 1.6.2 - Straw Electronics-
  - includes front-end electronics, High and Low Voltage power supplies and cables.
- 1.6.3 - “Other” Mechanical Subsystems
  - Gas system, temperature control…
- 1.6.4 - Hardware and Software specific to Straw Detector
  - Test Stations with database connections
  - Fast Interlocks and Slow Controls
- 1.6.5 - Management

Straw Detector Participants WBS 1.6

- **Fermilab: A.A. Hahn, P. Kasper, H. Cease, J. Howell, J. Krider, A. Lee, D. Olis, T. Tope, W. Stuermer, C. Serritella, Z.Shi, D. Butler, B. Pritchard, Y. Orlov**
- **Frascati: F. Bellucci, M. Bertani, L. Benussi, S. Bianco, M. A. Caponero, F. Fabbri, F. Felli, M. Giardoni, G. Mensitieri, A. La Monaca, E. Pace, M. Pallotta, A. Paolozzi, B. Ortenzi**
- **Southern Methodist University: T. Coan, M. Hosack**
- **University of California, Davis: P.Yager**
- **University of Houston: K. Lau, B. Mayes, G. Xu, Siva Subramania, A. Daniel, M.Ispiryan**
- **University of Virginia: M. Arenton, S. Conetti, B. Cox, A. Ledovskoy, M.Ronquest, D. Smith, D. Phillips, H. Powell, W. Stephens**

-Physicist

- Technical staff

Straw Organization — WBS 1.6

WBS 1.6
A. Hahn

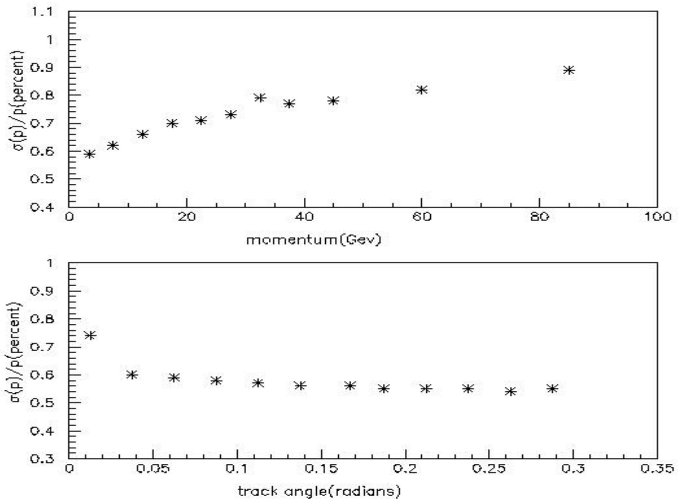
- **1.6.1** Straw Detectors — J. Krider — $5.9M
- **1.6.2** Straw Electronics — W. Stuermer — $2.1M
- **1.6.3** Other Mech. Subsytems — D. Olis — $740k
- **1.6.4** Integration & Testing — P.Kasper — $320k
- **1.6.5** Straw Management — $561k

Base cost: $9.5M (Material: $5.1M, Labor: $4.4M)

Technical Description of Straw Tracker WBS1.6

- **Straws: chosen because of of small cell size (segmentation)**
- **Uses Atlas design as basis**
- **0.8% Xo per station**
- **Tracking resolution: 150μm/view**
- **Momentum resolution better than 1% over full momentum and angle range**

Straw size	4 mm, 8mm diameter
Central dead region	26 cm x 26 cm
Number of Stations	7
Z positions (cm)	96, 138, 196, 288, 332, 382, 725
Active Half size (cm)	27.2, 40.8, 61.2, 88.4, 102, 115.6, 197.2
Views per station	3
Layers per view	3
Total number of straws	26784
Total station thickness	0.8% X_0
Total channels	53568
Readout	ASDQ + TDC(8 bits), sparsified



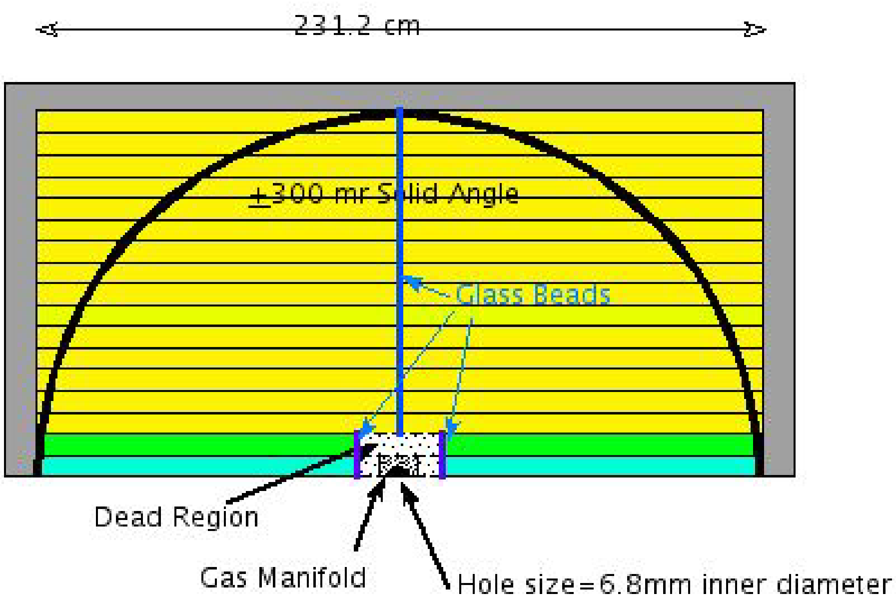
Momentum resolution

Straw Detector – “half-view”

Assembled in groups of 48 straws - Modules

Station # 6 HalfView

(More or less to scale)



17 modules/HalfView
Mod type 1=96 straws (short straw)
Mod type 2=48 straws
Mod type 3=720 straws

total=864 straws

Mod type 1 (96 4mm diameter Straws, gas Manifold and 27 cm dead region)

Mod type 2 (48 4mm diameter Straws, 27 cm dead region)

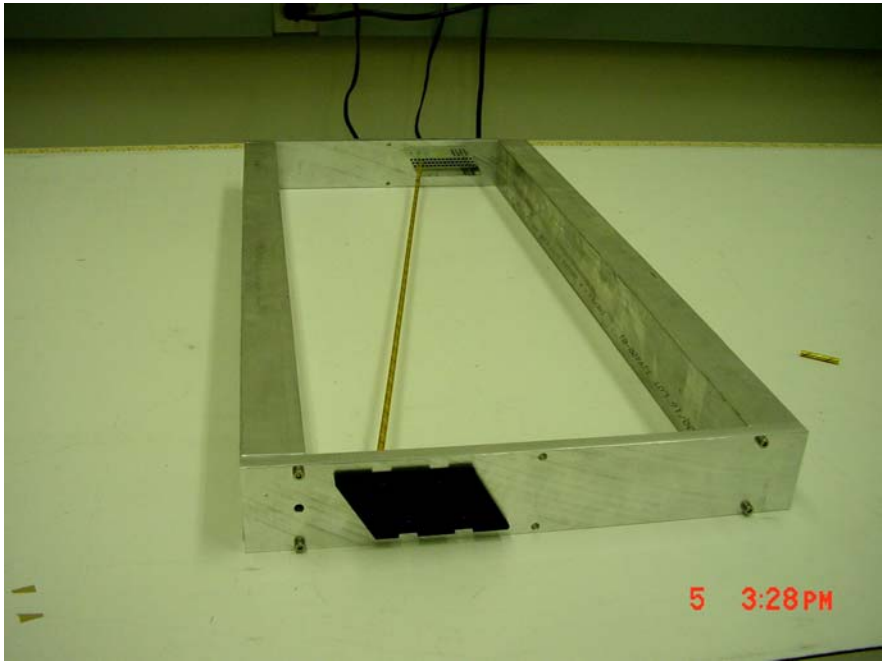
Mod type 3 (48 4mm diameter Straws)

4mm modules have 3 planes of 16 straws

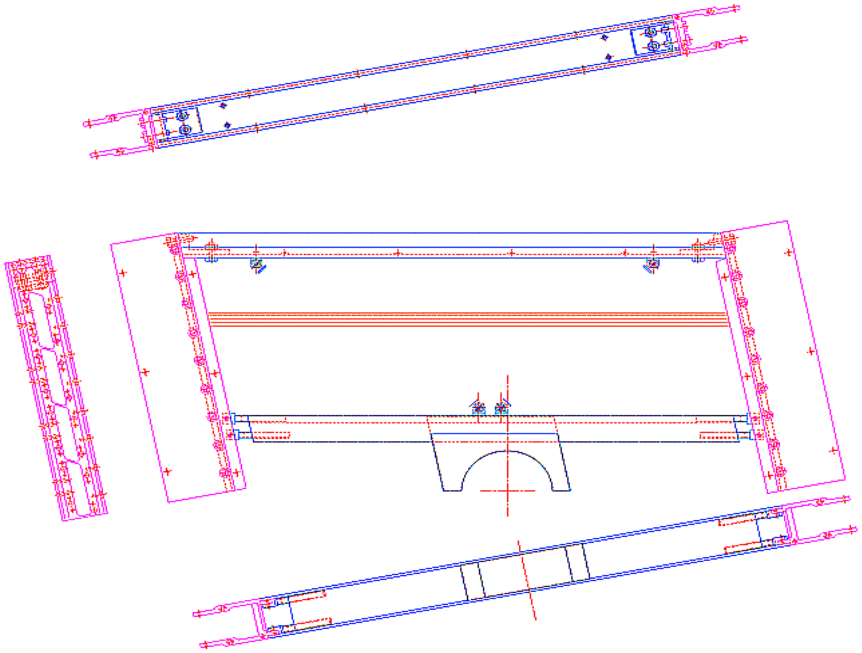
module is 6.8cm high (6.4 mm straws+2mm gap each side)

Straw Detector Stations 1 & 2

Straw Length =54 cm
384 Straws/View
1152 Straws/station

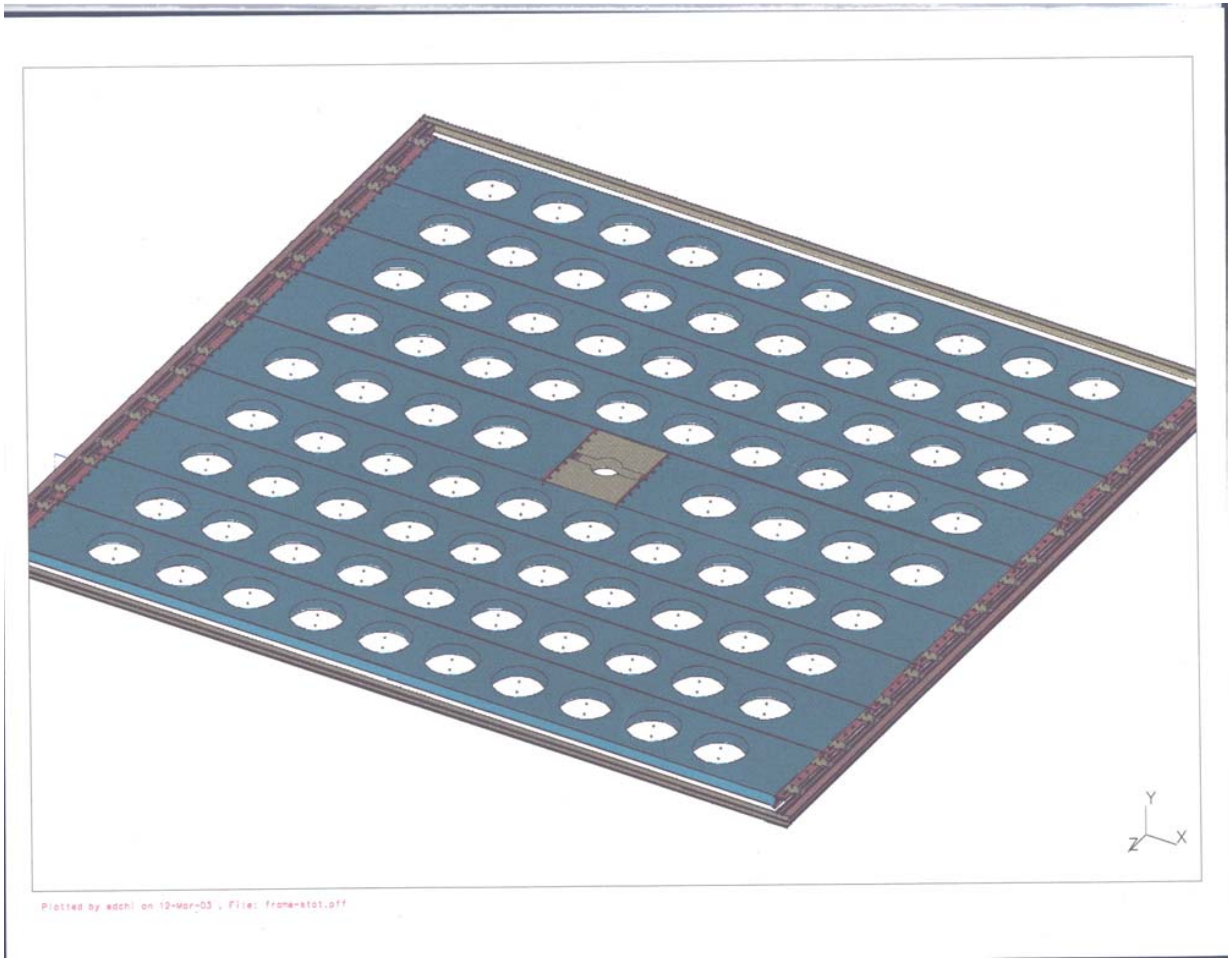


Station 1 "Prototype" Frame



Station #1 U,V HalfView Frame.
X View is simple rectangular shape

Straw Detector Station 7



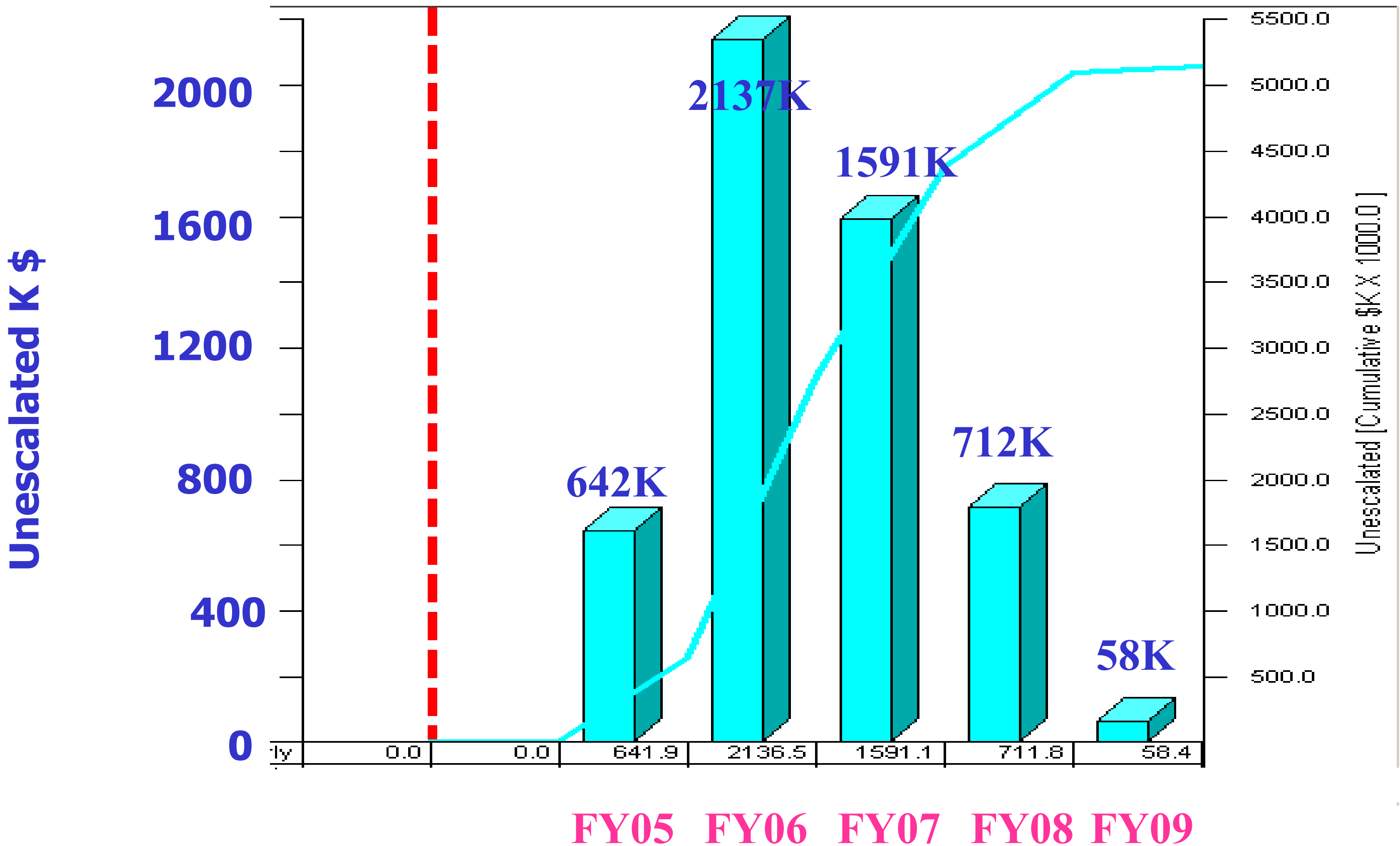
Station 7 View constructed of “SuperModules”

Straw Tracker Construction Cost WBS 1.6

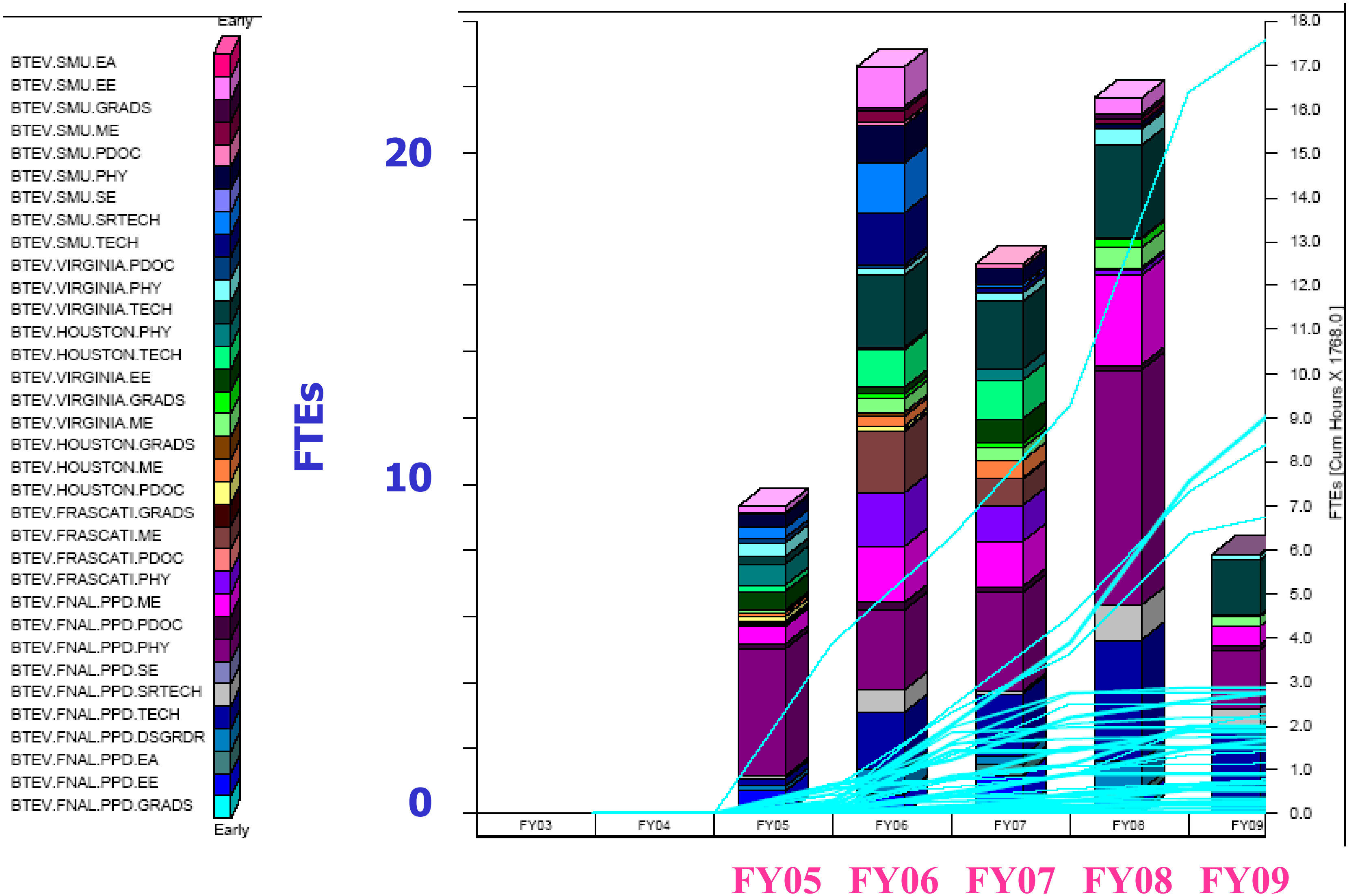
Activity ID	Activity Name	Base Cost($)	Material Contingency (%)	Labor Contingency (%)	Total FY05	Total FY06	Total FY07	Total FY08	Total FY09	Total FY05-09
1.6.1	Straw Chambers	5,850,421	23	29	470,866	3,278,268	1,704,144	1,340,729	569,488	7,363,495
1.6.2	Straw Detector Electronics	2,055,682	30	43	595,320	480,970	1,068,940	558,100	48,953	2,752,282
1.6.3	Mechanical Gas Calibration & Other Support Systems (FNAL SMU)	740,788	30	37	40,769	204,225	175,834	553,044	18,213	992,084
1.6.4	Integration & Testing (all)	320,177	31	71	130,235	101,553	129,286	41,698	31,739	434,511
1.6.5	Forward Tracker Straw Detector Subproject Management	560,945	30	30	150,030	152,421	150,627	150,627	125,523	729,228
1.6	**Subproject 1.6**	**9,528,012**	**26**	**32**	**1,387,220**	**4,217,436**	**3,228,831**	**2,644,198**	**793,915**	**12,271,600**

M&S Obligation Profile by Fiscal Year WBS 1.6

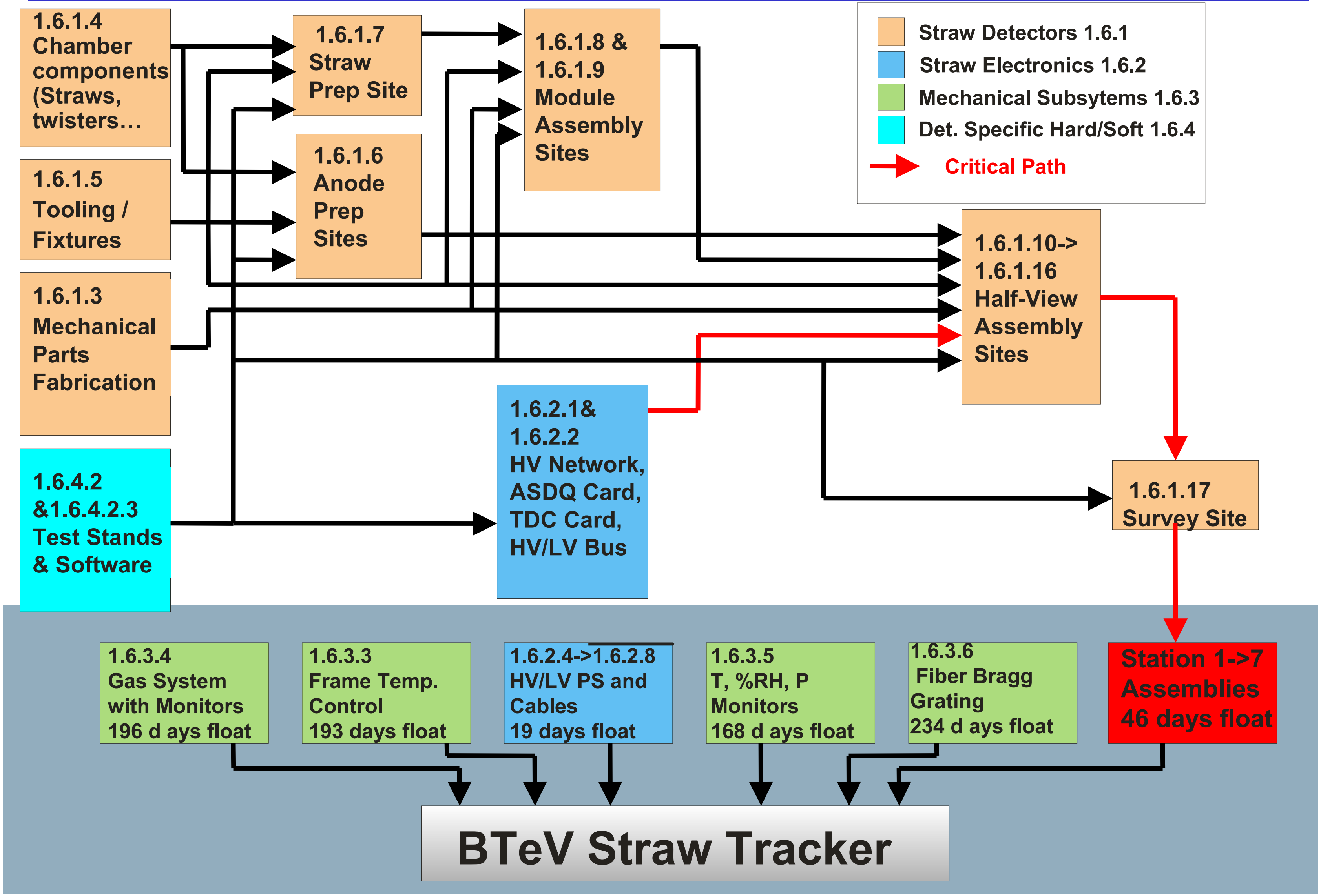
Total: 5140 k$



Labor Profile by Fiscal Year WBS 1.6

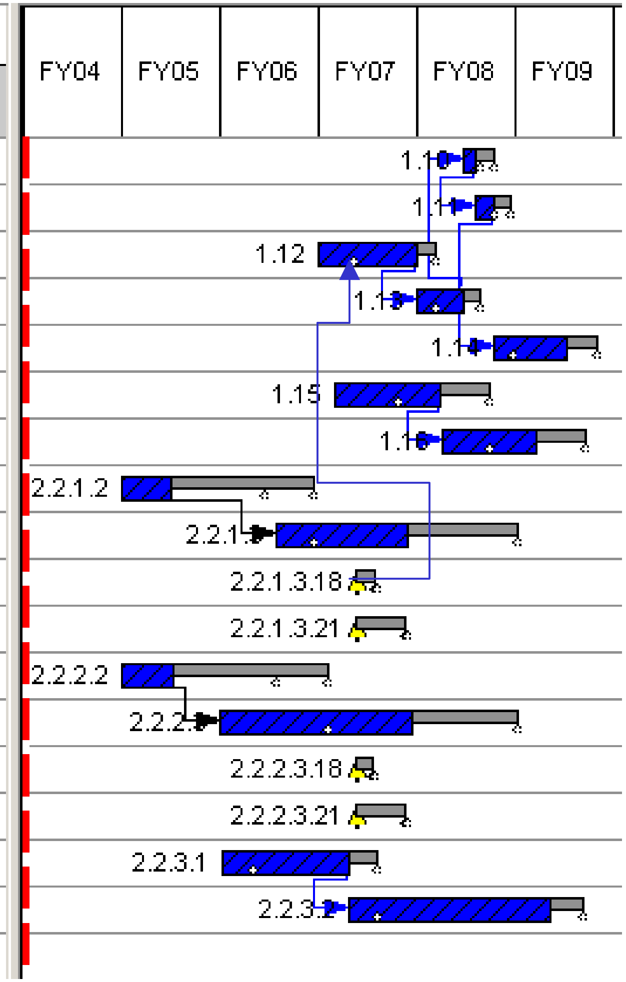


Description of Straw Project Flow WBS 1.6



Gantt Chart For Critical Path WBS1.6

Activity ID	Activity Description	Total Cost	Early Finish	Float
1.10	Straw Station #1 Half-View Assembly Site (UVa)	$43,482	13May08	45.80d
1.11	Straw Station #2 Half-View Assembly Site (UVa)	$56,769	17Jul08	45.80d
1.12	Straw Station #3 Half-View Assembly Site (UVa)	$89,209	03Oct07	45.80d
1.13	Straw Station #4 Half-View Assembly Site(UVa)	$112,205	24Mar08	45.80d
1.14	Straw Station #5 Half-View Assembly Site(UVa)	$136,994	17Apr09	45.80d
1.15	Straw Station #6 Half-View Assembly Site (FNAL)	$226,161	04Jan08	123.90d
1.16	Straw Station #7 Super Module Assembly Site (FNAL)	$310,688	23Dec08	123.90d
2.2.1.2	Complete Design HV Network Board	$41,497	08Apr05	367.80d
2.2.1.3	Production Assembly and Test of HV Network Board	$281,293	29Aug07	45.80d
2.2.1.3.18	Lev3Mil: HV Network Card for S#3	$0	22Feb07	45.80d
2.2.1.3.21	Lev3Mil: HV Network Card for S#6	$0	23Feb07	124.90d
2.2.2.2	Complete Design PDB	$24,346	15Apr05	400.60d
2.2.2.3	Production Assembly and Test of PDB	$342,761	21Sep07	47.60d
2.2.2.3.18	Lev3Mil: PDB for S#3	$0	20Feb07	47.60d
2.2.2.3.21	Lev3Mil: PDB for S#6	$0	20Feb07	126.90d
2.2.3.1	Complete Design TDC/SI Board	$71,289	25Jan07	74d
2.2.3.2	Production TDC/SI Board	$248,430	12Feb09	74d



Critical Path Analysis WBS 1.6

- Straw Stations ready for Installation
  - The current production scheme builds (S3,S4,S1,S2,S5, TF=46 days) and (S6, S7 TF=124 days) at two parallel production sites.
    - The production time scales are set by various assumptions on assembly lines (2/site) and a single shift. These assumptions (# sites, # assembly lines, # shifts, and order of station production) could be changed.
  - Critical path is also set by funding profile
    - Assume that we want Front End Electronics (HV Network and Preamp/discriminator Boards for testing of Detectors. This sets the 46 day total float.
    - This assumption could be modified for earliest detectors.
  - Target Date used was June 1, 2009, for Stations 1->3, and July 1, 2009 for Stations 4->7 (from Joe Howell 1.10)
    - Note: except for HV and LV Power supplies, where the target date was Jan 31, 2008.

Straw Level 2 Milestones WBS1.6

WBS1.6	Forward Straw Tracker	Date
1.6.2.3.1.1.9	ASDQ Chip Procurement Initiated	October 2004
1.6.2.3.1.1.10	ASDQ Procurement Complete	August 2005
1.6.1.7.1.2.13	Straw Preparation Site Functional	March 2006
1.6.1.12.1.2.6	Half-View Production/ Assembly Sites Functional	February 2007
1.6.6.4.1	Station 1 ready for Installation	February 2009
1.6.6.4.7	Station 7 ready for Installation	March 2009

Straw Risk Analysis WBS1.6

Risk Event	Mitigation
Major Construction Problems with Half View Production	The best strategy is to have a robust production prototype construction so that we can identify production problems before we actually enter production. A standby strategy is to have backup sites which could contribute to Half-View production once their original function is accomplished. For example, once the Straw Preparation Facility has finished, it could convert to a Half-View Assembly site.
Process to produce ASDQ chips is shutdown, by the time our budget profile allows us to place order.	We need to identify a source of funds that allows us to commit to a wafer run as early in the project as possible-while the current wafer process still exists. We could delay the packaging to later in the project timeline, when more funds become available.

Silicon Strip Components WBS 1.7

Base cost: $7.5M (Material: $3.6M, Labor: $3.8M)

- Sensors
- Readout Chips
- Electronics Packaging & DA
  - Hybrids, Flex's, Junction Cards, Power Supplies, Cabling and DCB's
- Mechanics
  - Inner & Outer Supports
- Cooling
- Ladder Assembly
- System Integration & Testing
  - Detector Prototypes & Tests, Control & Monitor, Detector Specific Software

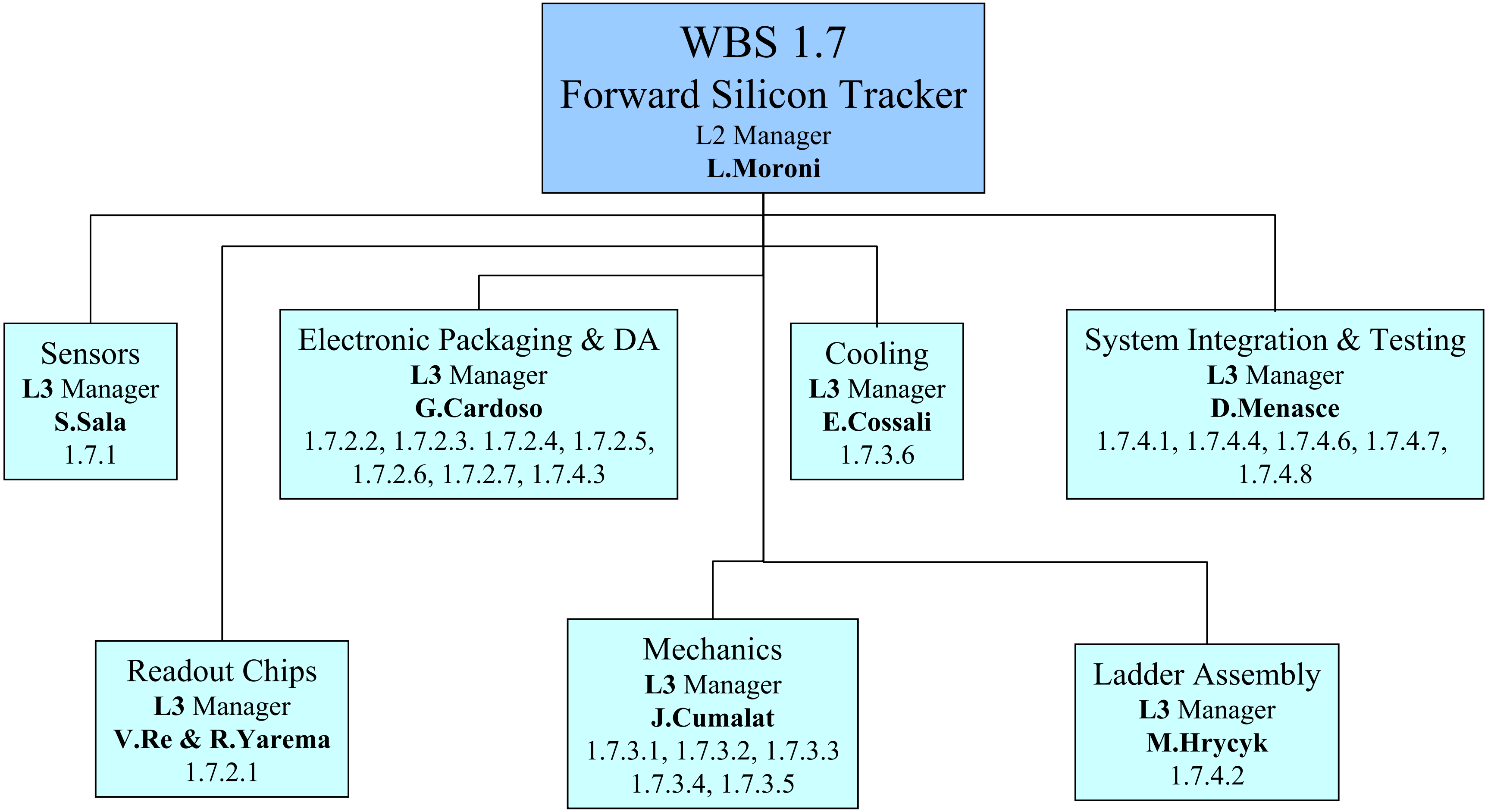
Silicon Tracker Participants WBS 1.7

- Colorado University: J.Cumalat, P.Rankin, Eric Erdos
- Fermilab: J. Andresen, G. Cardoso, C. Gingu, J. Hoff, M. Hrycyk, A. Mekkaoui, R. Yarema, J. Andresen, K. Knickerbocker, A. Dyer
- Insubria University: P. Ratcliffe, M. Rovere
- INFN Milano: G. Alimonti, M. Citterio, S. Magni, D. Menasce, L. Moroni, D. Pedrini, S. Sala, S. Erba, P. D'Angelo, S. Latorre, M.Malatesta
- INFN Pavia: G.E. Cossali, P.F. Manfredi, M. Manghisoni, M. Marengo, L. Ratti, V. Re, M. Santini, V. Speziali , D. Di Pietro, G. Traversi , K. Fisher, L. D'Angelo

-Physicist

- Technical staff

Silicon Tracker Organization WBS 1.7

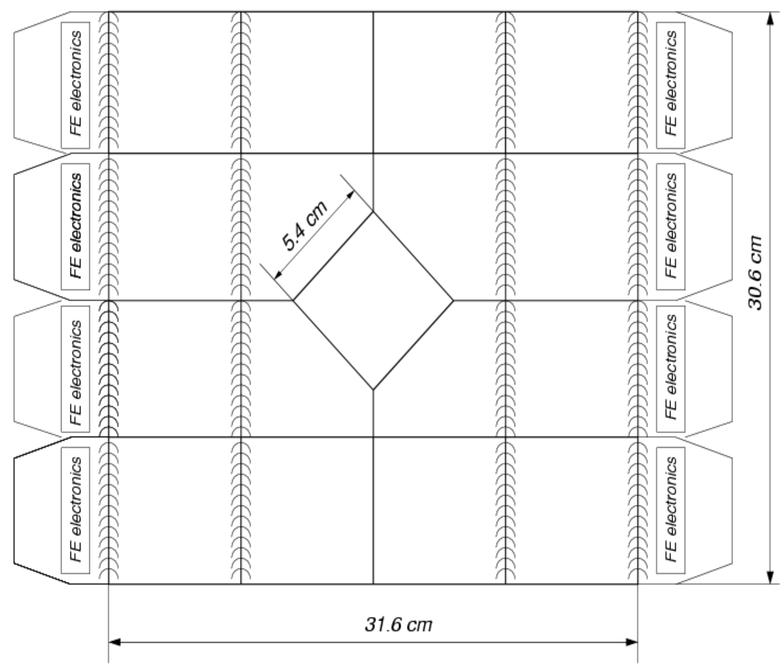


Base cost: $7.5M (Material: $3.6M, Labor: $3.8M)

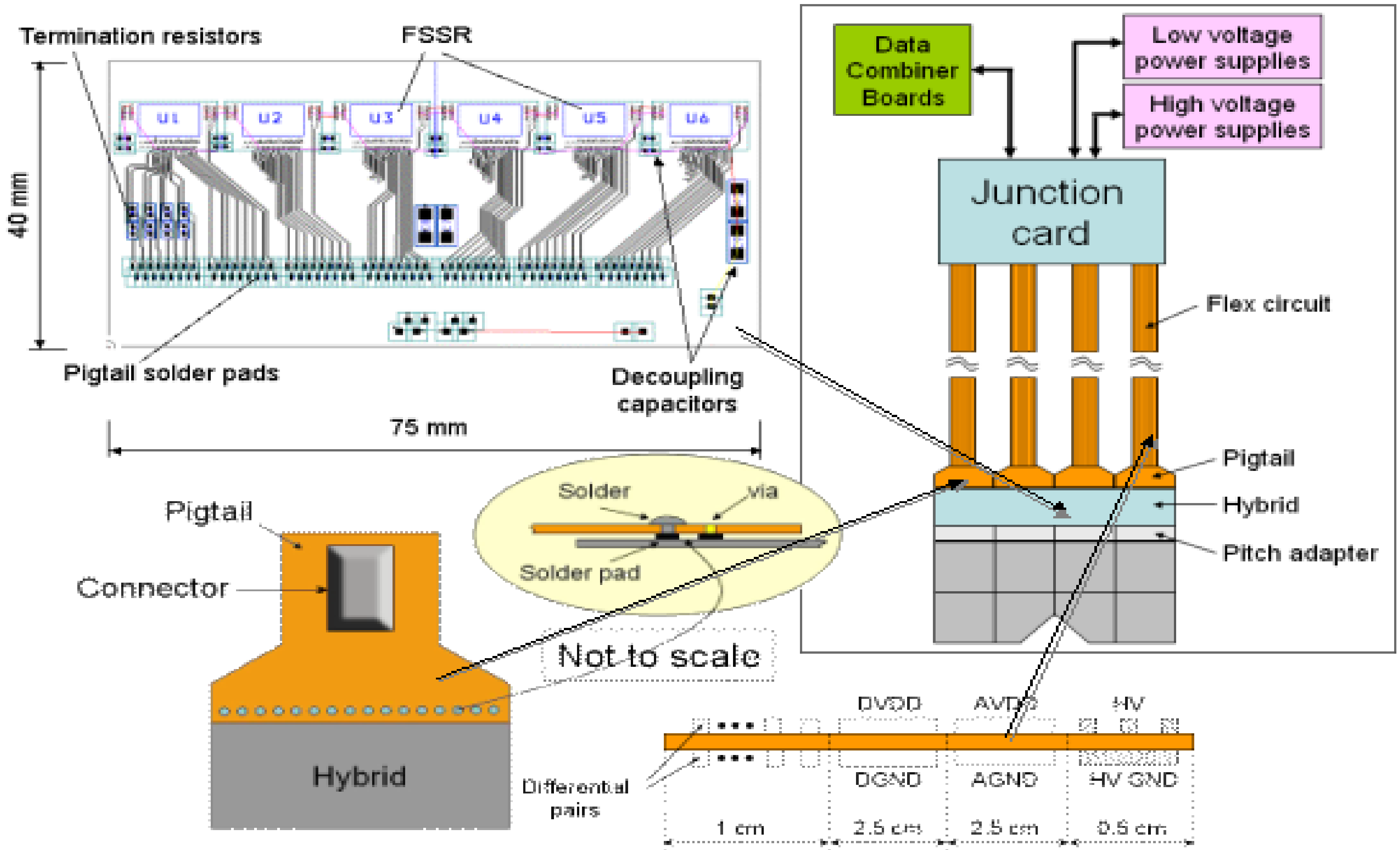
Technical Description of Silicon Tracker WBS1.7

- **Silicon Strips: simple single sided p⁺/n design (CMS design)**
- **7 stations**
  - **3 in dipole fringe field**
  - **3 before RICH**
  - **1 after RICH**
- **Coverage from beam pipe to ±15.5cm from the beam**
- **Each station has 3 planes of 320 μm thick SMD with 100 μm pitch**
- **Each detector is 7.9 cm x 7.9 cm**
- **Four detectors form one ladder with readout at both ends**
- **New readout chip (FSSR) using 0.25μm CMOS**

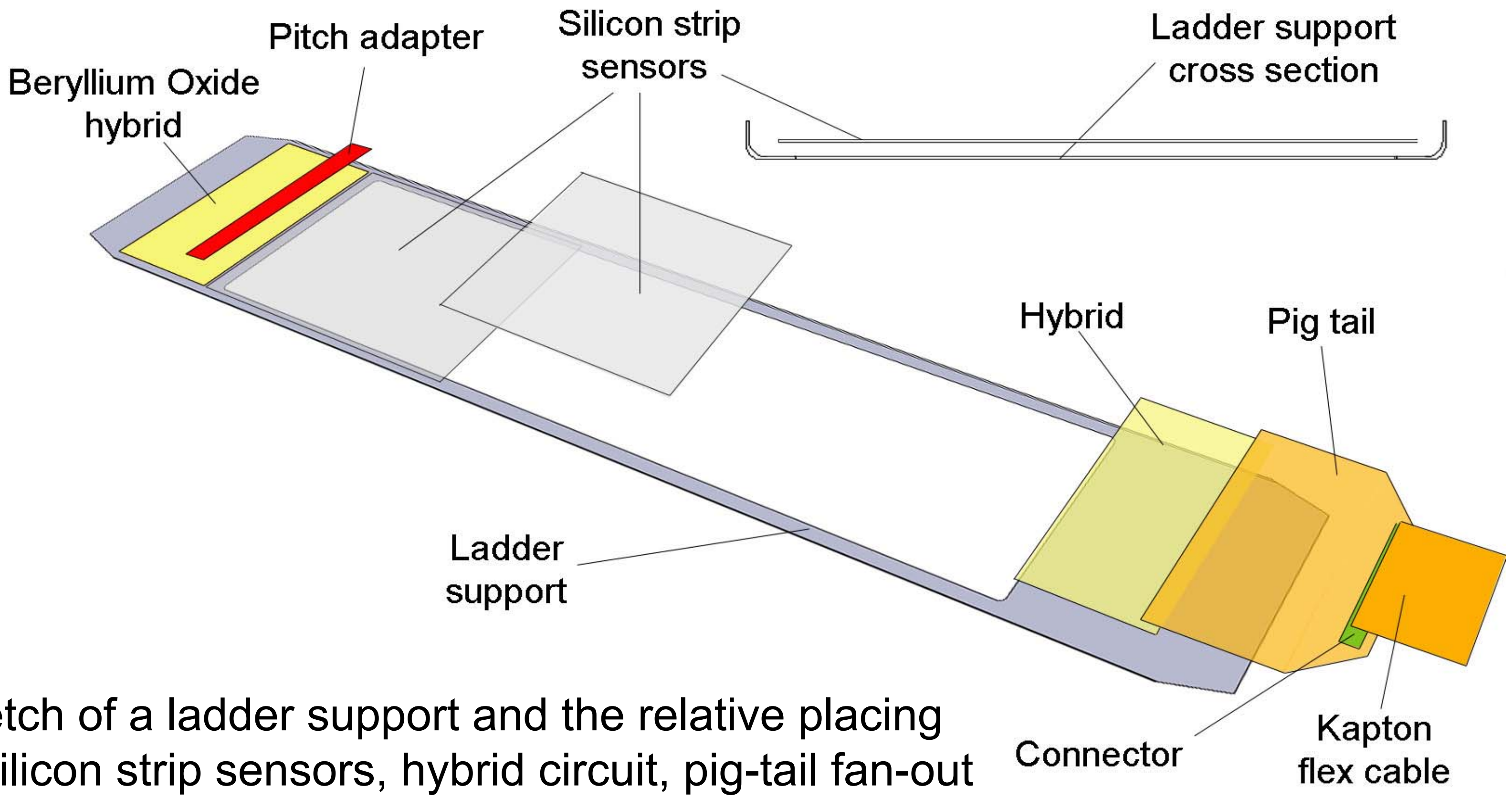
Property	Value
Silicon Sensors	$\sim 7.9 \times 7.9$ cm^2, p-on-n type
Pitch	100 μm
Thickness	320 μm
Sensor configuration	4 ladders with 4 sensors each
Coverage	30.6×31.6 cm^2
Central Hole	5.4×5.4 cm^2 (7×7 cm^2 for last station)
Total Stations	7
Z Positions	85.5, 127.5, 185.5, 277.5, 321.5, 371.5, 714.5
Views per Station	3 (X,U,V)
Channels per view	6,144
Total Channels	129,024
Readout	Sparsified Binary



Benefit from CDF RUN IIB experience

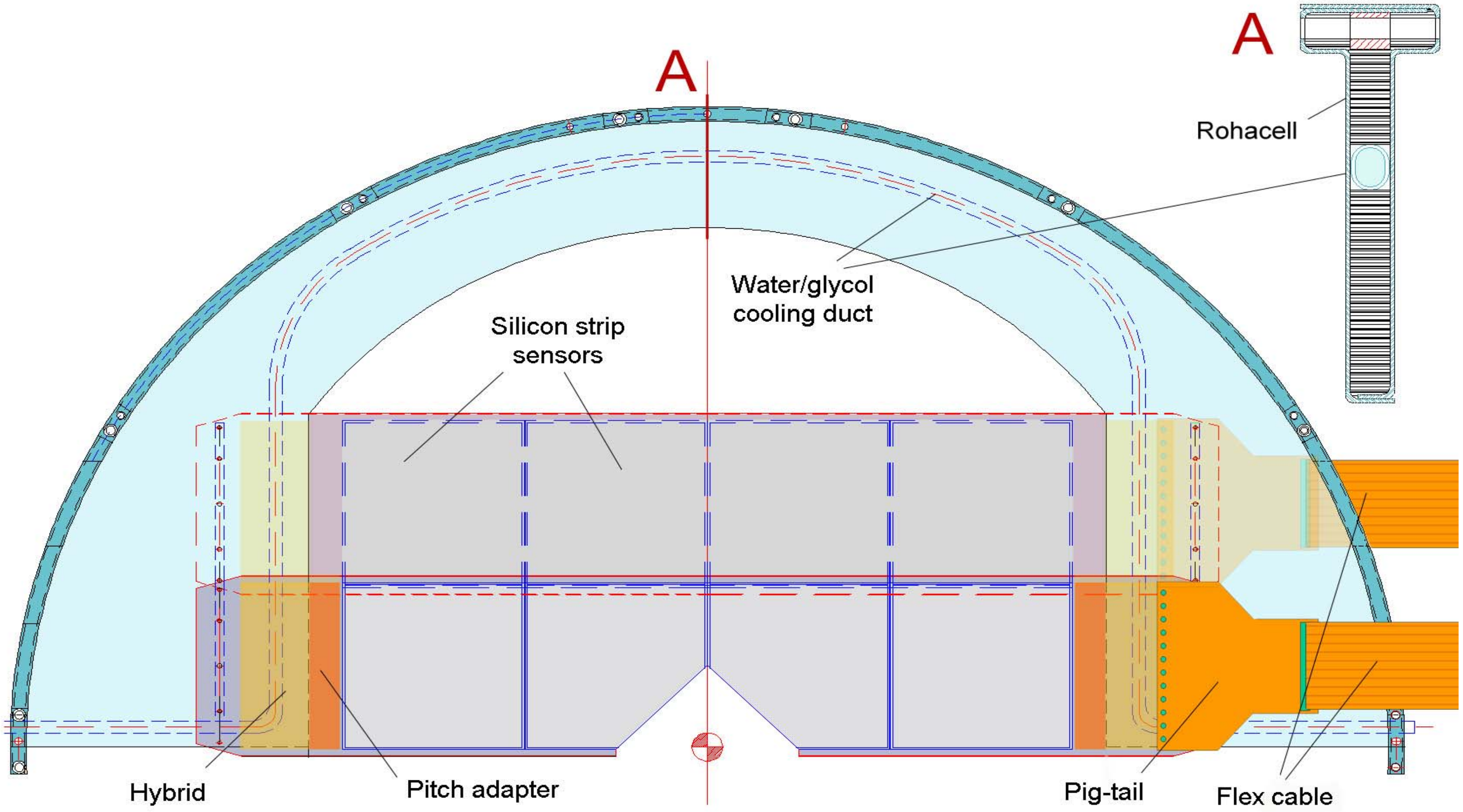


Silicon Strip Detector Ladder Support WBS1.7



Sketch of a ladder support and the relative placing of silicon strip sensors, hybrid circuit, pig-tail fan-out and kapton flex cable.

Silicon Strip Detector Half Plane Support

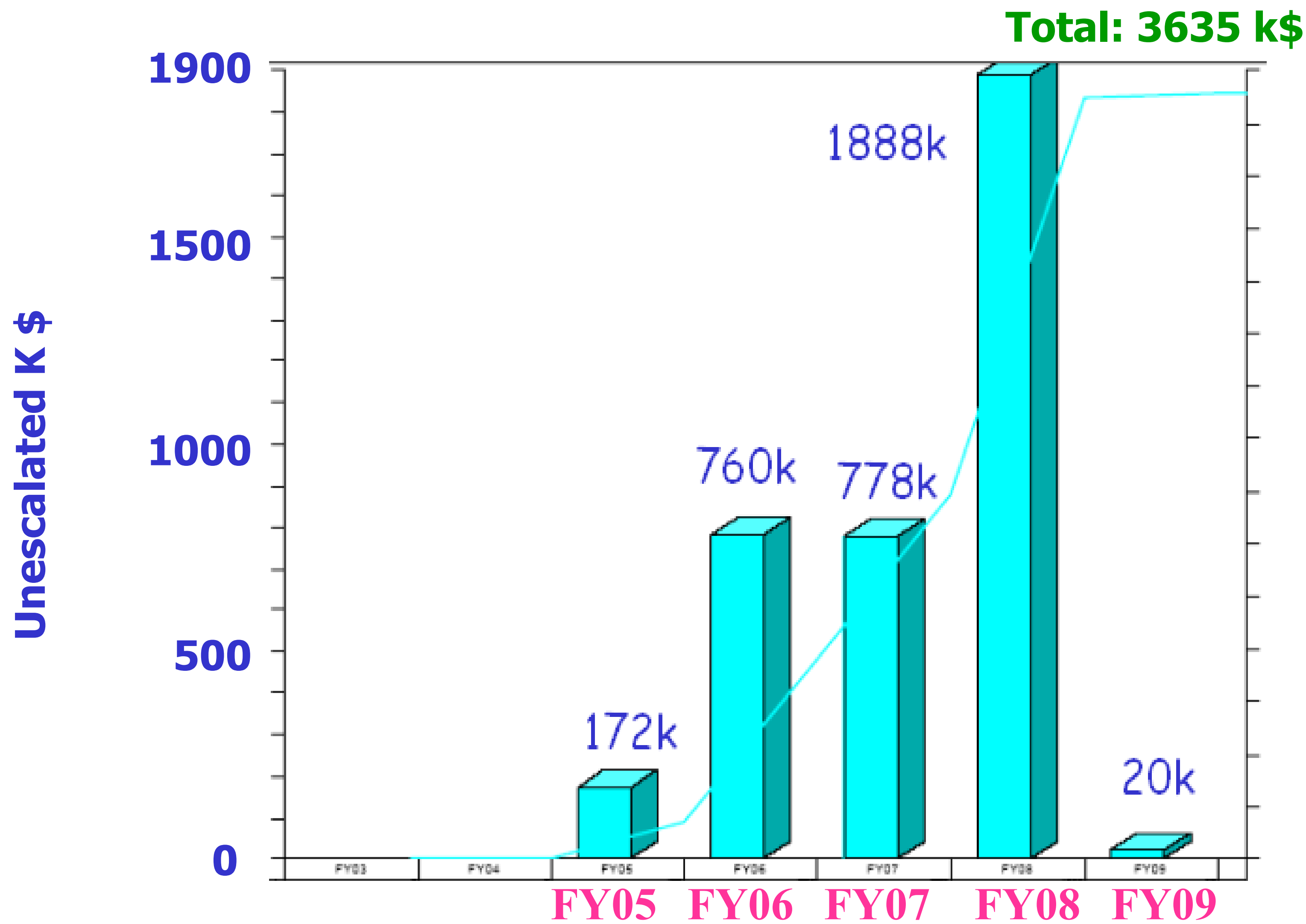


BTeV Co

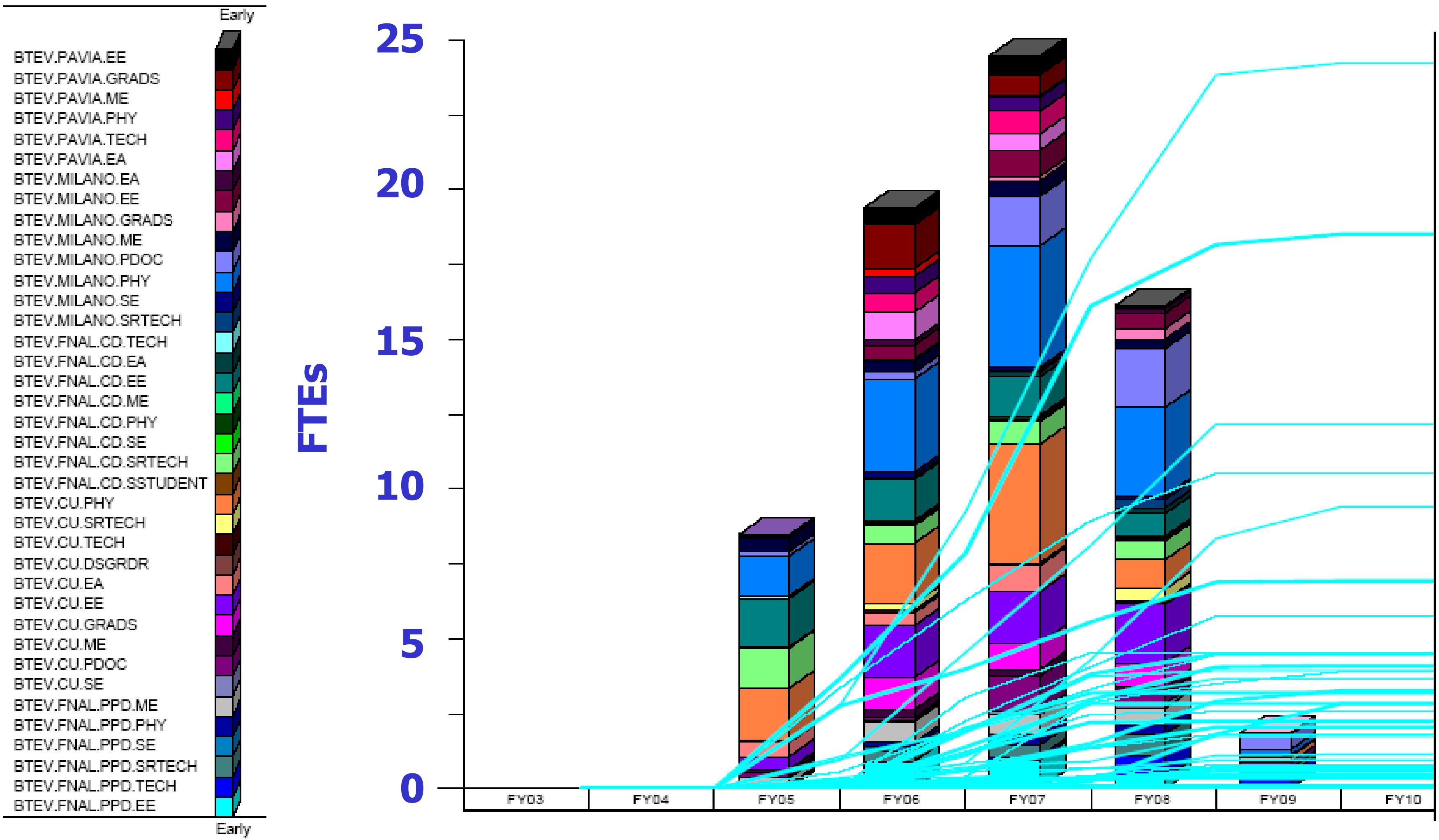
Silicon Tracker Construction Cost WBS1.7

Activity ID	Activity Name	Base Cost($)	Material Contingency (%)	Labor Contingency (%)	Total FY05	Total FY06	Total FY07	Total FY08	Total FY09	Total FY05-09
1.7.1	Sensors (SM)	1,087,865	25	28	0	185,079	179,661	996,564	0	1,361,304
1.7.2	Electronics	2,273,506	31	27	279,813	831,743	975,683	850,129	2,969	2,940,336
1.7.3	Mechanics & Cooling	983,248	53	45	104,689	495,870	305,914	521,253	46,545	1,474,271
1.7.4	Integration	2,026,580	46	37	500,509	537,839	650,432	1,066,521	89,068	2,844,370
1.7.6	Detector Subproj Mgmt	1,102,189	30	26	152,373	426,979	421,956	388,467	0	1,389,774
1.7	**Subproject 1.7**	**7,473,388**	**36**	**32**	**1,037,385**	**2,477,510**	**2,533,646**	**3,822,933**	**138,581**	**10,010,055**

M&S Obligation Profile by Fiscal Year WBS1.7

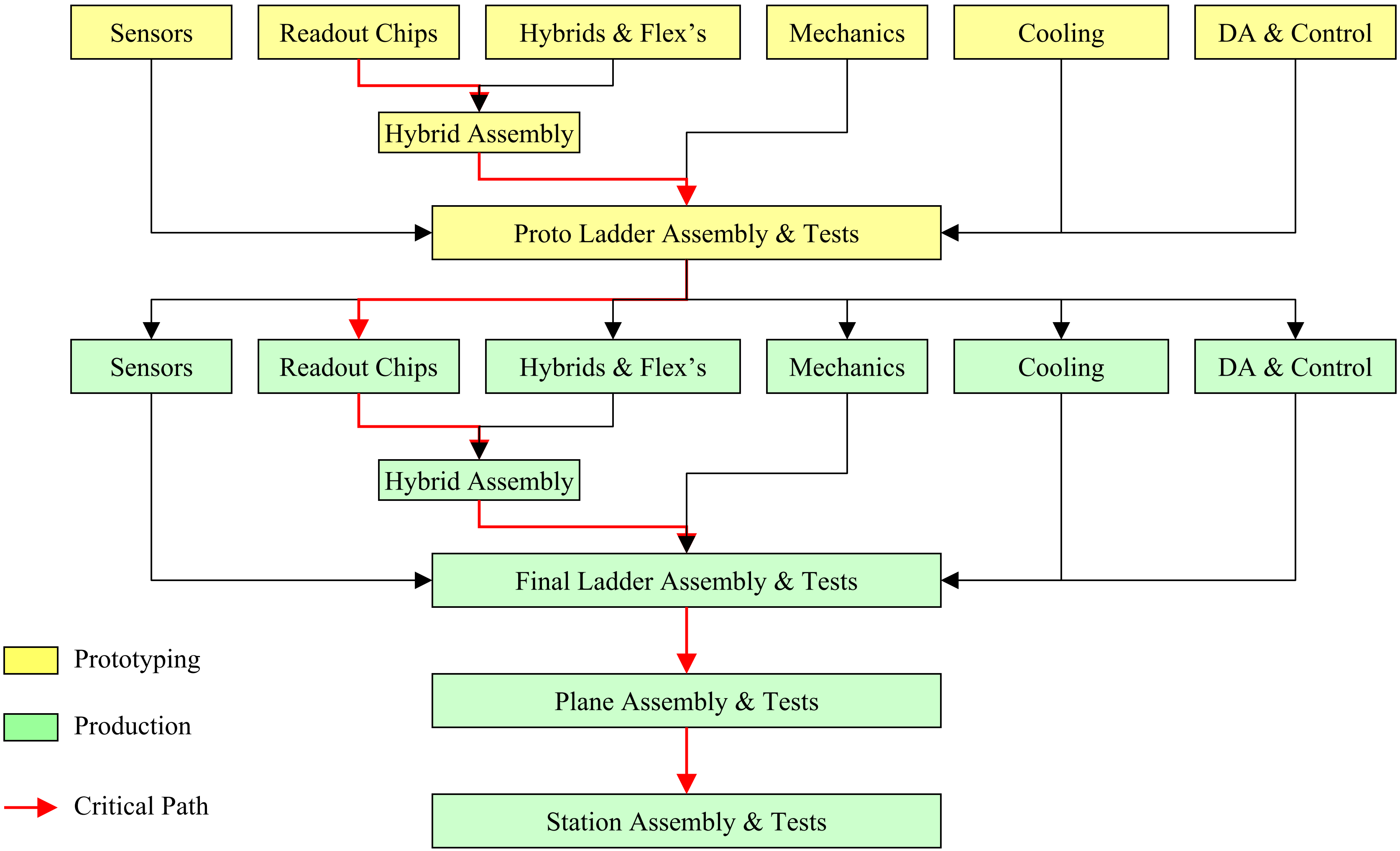


Labor Profile by Fiscal Year WBS 1.7



FY05 FY06 FY07 FY08 FY09

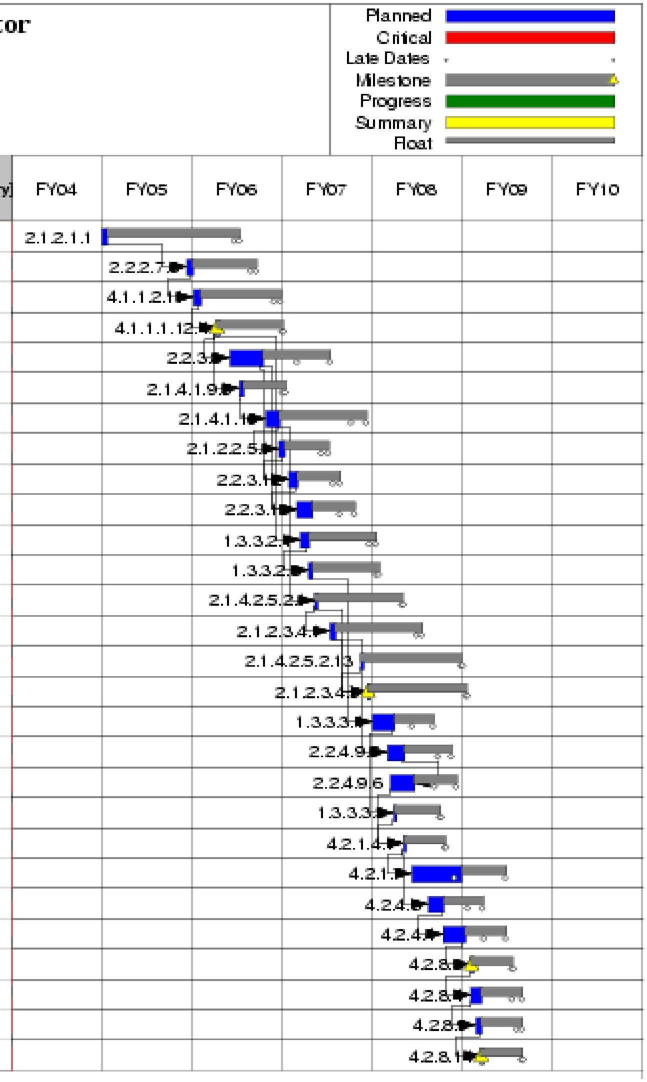
Description of Project Flow WBS 1.7



Gantt Chart for Strip Detector WBS1.7

BTeV - WBS 1.7 Forward Tracker Strip Detector
Barchart for Critical Path Analysis
Sorted by Float

Activity ID	Activity Description	Float	Early Start	Early Finish	ory]
2.1.2.1.1	Thinning, Coating & Dicing Tested Pass Two IC Proto	372d	01Oct04	21Oct04	*
2.2.2.7.6	Test Assembled Proto Hybrid for Ladder Tests	182d	16Sep05	06Oct05	*
4.1.1.2.11	Assemble & Test Ladder Proto at SiDet	227d	10Oct05	04Nov05	*
4.1.1.1.12.4	Lev2Mil: Ladder Prob Results Revwd & RecommendationsMa	182d	13Jan06	13Jan06	*
2.2.3.8	Procure Preproduction Hybrids	188d	08Mar06	13Jul06	*
2.1.4.1.9.5	Obt Approvals for & Order Pre-Prod Run of Final ICs	120d	17Apr06	28Apr06	*
2.1.4.1.10	Test Pre-Prod Run of Final ICs	243d	26Jul06	20Sep06	*
2.1.2.2.5.1	Thinning, Coating & Dicing Tested Pre-Prod IC	120d	21Sep06	11Oct06	*
2.2.3.12	Vend Assemblies & Tests Hybrids with Pass Three ICs	120d	02Nov06	01Dec06	*
2.2.3.13	Test Assembled Preproduction Hybrids for Station Tests	120d	04Dec06	31Jan07	*
1.3.3.2.1	Manufacture, Test & Ship Pre-Prod Shipment of SM Sensors S1	191d	15Dec06	16Jan07	*
1.3.3.2.3	Part Accept Test of Pre-Prod SM Sensors	191d	17Jan07	30Jan07	*
2.1.4.2.5.2.1	Lev3Mil: Receive 1st Shipment of ICs	243d	12Feb07	12Feb07	*
2.1.2.3.4.1	Thinning, Coating & Dicing 1st Shipment of ICs	243d	13Apr07	03May07	*
2.1.4.2.5.2.13	Lev3Mil: Production ICs received & tested	278d	20Aug07	20Aug07	*
2.1.2.3.4.5	Lev2Mil: Production ICs Received, Tested & Thinned	278d	11Sep07	11Sep07	*
1.3.3.3.1	Manufacture, Test & Ship 1st Shipment of Prod SM Sensor S1	112d	01Oct07	27Dec07	*
2.2.4.9.5	Vend Assemblies & Tests Hybrids for Ladder Production	140d	05Dec07	05Feb08	*
2.2.4.9.6	Test Assembled Production Hybrids for Ladder Production	120d	19Dec07	18Mar08	*
1.3.3.3.3	Lev3Mil: Received 1st Shipment of SM Sensor	127d	27Dec07	27Dec07	*
4.2.1.4.1	Lev3Mil: Start Receiving Ladder Prod Components	120d	06Feb08	06Feb08	*
4.2.1.7	Assemble & Test Ladders at SiDet	122d	12Mar08	24Sep08	*
4.2.4.3	Vend Assemble & Test Ladder Prod	112d	15May08	15Jul08	*
4.2.4.4	Receive & Test Ladder Prod from Vend	112d	16Jul08	08Oct08	*
4.2.8.3	Lev2Mil: Ladder Burn-in Compl	112d	05Nov08	05Nov08	*
4.2.8.4	Assemble Planes from Ladders & Test at SiDet	112d	06Nov08	12Dec08	*
4.2.8.9	Assemble Stations from Planes & Test at SiDet	112d	26Nov08	17Dec08	*
4.2.8.14	Lev2Mil: FSIL Stations Assembled & Tested	112d	17Dec08	17Dec08	*



Critical Path Analysis

- The shortest Total Float in the Forward Silicon Strip project is 112 days
  - i.e. any delay up to 6 months can be absorbed by our schedule without impacting the deadline for installation on June 09.
- Furthermore,
  - Several activities on the Critical Path can be delayed by a few additional months without impacting the previous value of the total float

Key Milestones

Milestone	Date
Sensor accepted for full production	Feb-07
Production sensors received and tested	Jul-08
Readout IC approved for production	Oct-06
Production ICs Received tested and thinned	Sep-07
Hybrids approved for production	Feb-07
Hybrids complete and tested	Mar-08
Station support procurement complete	Sep-08
Ladder production 100% Complete	Oct-08
First FSIL station ready to be installed in C0	Nov-08
Last FSIL station ready to be installed in C0	Dec-08

Risk Analysis

- Risks

  1. 0.25μm CMOS process disappears before we go into production

- Mitigation

  1. Work with multiple vendors. Keep in close contact with vendors to understand their future plans.

Summary for WBS 1.2, WBS 1.6, and WBS 1.7

More information on the Pixel (WBS 1.2), Straw (WBS 1.6) and Silicon Strip Tracker (WBS 1.7) is available in the breakout sessions.

WBS 1.2

- **Overview – D. Christian (today at 4:00pm)**
- **Sensor & hybridization – S. Kwan**
- **Electronics – G. Cardoso**
- **Substrate & half-plane assembly – CM Lei**
- **Cooling and Vacuum system – M. Wong**
- **Pixel Detector assembly – J. Fast**
- **Test beam & slow control – C. Newsom**
- **Cost and Schedule – S. Kwan**

WBS 1.7

- **Overview – L. Moroni (today at 4:30pm)**
- **Readout chip – V. Re**
- **Readout electronics – G. Cardoso**
- **FBG sensors for position monitoring – M. Caponero**
- **Software for test stand and DAQ – D. Menasce**
- **Cost and Schedule – L. Moroni**

WBS 1.6

- **Overview – A. Hahn**
- **Occupancies and Track efficiencies – P. Kasper**
- **Straw Production, Cost & Schedule – A. Hahn**
- **Straw Chamber Assembly – Y. Orlov**
- **MOX – A. Paolozzi**
- **Preliminary results from test beam – M. Arenton**
- **UVa BTeV Straw Project R&D and Site Preparation – B. Cox**
- **Aging studies and Leak Detector Development - K. Lau**

Conclusion

- The BTeV tracking system has three elements: Pixel vertex detector, forward silicon tracker, and forward straw detector
- For all three detectors:
  - Baseline technical designs exist
  - Organization structure established
  - Detailed WBS leading to a base cost estimate and resource-loaded schedule for the construction of the baseline detector
  - We are ready to move on to the next phase of the project

Pixel Glossary of Terms
WBS1.2

- HDI – High Density Interconnect
- PIFC – Pixel Interconnect Flex Cable
- FTB – Feed-through Board
- TPG – Thermal Pyrolytic Graphite
- PGS – Pyrolytic Graphite Sheet
- LN2 – Liquid Nitrogen
- PDCB – Pixel Data Combiner Board

Straw Glossary of Terms WBS 1.6

- Module : basic construction unit consisting of 48 straws
- Half-Views: Each Straw Station is made of 3 views (X, U, V). Each View is divided into two "Half-Views", in order to install detector around an existing beam pipe. Each Half-View is an independent working detector.
- ASDQ chip – Amplfier, Shaper, Discriminator and Charge chip; designed by the Upenn group and used in CDF COT
- MOX – Module O (closest to the beam pipe) X view

Silicon Strip Glossary of Terms

- FSSR: Fermilab Silicon Strip Readout Chip
- DCB: Data Combiner Board (note: Pixel and silicon strip will use the same type of DCB)
- DA: Data Acquisition
- FBG: Fiber Bragg Grating